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An assessment of American plaice in Subdivision 3Ps

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Abstract

The stock of American plaice in Subdivision 3Ps has been under moratorium since September 1993. Catches averaged just under 4000 t during the 1980's but rapidly declined after 1991. There has been no directed fishery since the moratorium was instituted and catch has not exceeded 500 t. The fishery has changed substantially compared to the premoratorium period with a larger inshore component, a substantial truncation in the length distribution and a much higher percentage of females in the catch. Since 1992, research vessel surveys indicate that the stock has been at a very low level. There has been a slight increase since 1993 in both biomass and abundance indices but current biomass is only 16% and abundance 21% of the 1983-87 average. Since 1993, female SSB calculated from the Campelen series has been only 15% of the 1986-87 average. Analyses of recruitment from survey data indicated that the 1977 and 1978 year classes were strong but that there were no good year classes between 1980 and 1992. Given the current low stock size and the lack of recruitment indicated by the surveys and the slow growing nature of American plaice there is little prospect of significant rebuilding in the short to medium term.

Résumé

Le stock de plie canadienne de la sous-division 3Ps fait l'objet d'un moratoire depuis septembre 1993. Les captures moyennes, étaient légèrement inférieures à 4 000 t au cours des années 1980, mais ont décliné rapidement après 1991. Il n'y a pas eu de pêche dirigée depuis l'imposition du moratoire et les captures n'ont pas dépassé les 500 t. La pêche a changé de façon appréciable par rapport à la période d'avant le moratoire : la composante côtière est plus importante, la distribution des longueurs est maintenant fortement tronquée et le pourcentage de femelles au sein des prises est beaucoup plus élevé. Depuis 1992, les relevés par navire de recherche indiquent un stock très appauvri. On a noté depuis 1993 une légère augmentation des indices de la biomasse et de l'abondance, mais la biomasse actuelle ne correspond qu'à 16 % et l'abondance qu'à 21 % de la moyenne pour la période 1983-87. Depuis 1993, la biomasse du stock de géniteurs femelles calculée à partir des séries de Campelen ne correspond qu'à 15 % de la moyenne de 1986-87. Selon des analyses du recrutement fondées sur les données des relevés, les classes annuelles de 1977 et 1978 étaient importantes, mais il n'y a pas eu de bonnes classes entre 1980 et 1992. Étant donné le faible niveau actuel du stock et l'absence de recrutement, indiqués par les relevés, et la lenteur du taux de croissance de la plie canadienne, les perspectives d'un rétablissement appréciable à court ou moyen termes ne sont pas très bonnes.

Description of the Fishery

Catches from this stock were highest from 1968 to 1973, exceeding 12,000 t on three occasions in this period (Fig. 1, Table 1). Catches by non-Canadian vessels peaked at about 8800 t in 1968, due mainly to the USSR catch, and have not exceeded 800 t since 1973. Since 1977 only Canada and France have been involved in this fishery. Catches averaged just under 4000 t during the 1980's but rapidly declined after 1991. Based on a recommendation by the FRCC the fishery was closed in September of 1993 for the remainder of that year. There has been no directed fishing since that time and catch has not exceeded 500 t. The catch in 1998 was 423 t and the catch to October 8, 1999 was 475 t.

Through the 1980's the majority of this fishery occurred in the offshore (Fig. 2). Both offshore and inshore catch declined substantially in the early 1990's and since 1995 the offshore catch has constituted less than 50% of the total. Prior to the moratorium, this fishery usually had a substantial main species American plaice component but this has been less than 50% of the total since then. In 1998, more than 50% of the catch came as bycatch in the cod fishery.

Sampling data from commercial fisheries, 1993-98

Minimal sampling data from commercial fisheries on this stock were available from 1994 to 1998. The 1993 catch at age was described in the last assessment of this stock (Morgan et al., 1995), where it was noted that no samples from fixed gear catches were taken in 1993, although catches from this sector comprised over 60% of the total. With the reduction in catches from the stock to around 100 tons per year in 1994-96, the number of commercial samples remained relatively low (1 length frequency in 1994, none in 1995, 4 in 1996). With the increase in catches in 1997 and 1998, more samples were available, although 1997 is the only year from 1993-98 in which length samples were taken from fixed gear catches, despite the predominance of this sector in the total landings (Table 2).

Otoliths were collected in all years except 1995, although these have not been aged due to reductions in personnel resources. Approximately 1172 otoliths have been collected from the commercial fishery in Subdiv. 3Ps during 1994-98, 47% of which are from 1998.

To determine whether the available sampling data could be used to estimate length and age compositions of commercial catches in 1993 to 1998, several comparisons were carried out. From previous years, it was observed that otter trawl and gillnet fisheries on this stock usually had different length and age compositions. Figs. 3 and 4 show these results from the 1990 commercial fishery, which was typical of most years (Brodie, 1991). As noted above, 1997 is the only year since 1992 in which a comparison of otter trawl and gillnet data can be made. Fig. 5 shows that the length compositions from these gears in 1997 were more similar to each other than in 1990, although they

were measuring different components of the population, as indicated by the much higher proportion of females in the otter trawl catches.

These comparisons also indicate that the length frequencies observed in the recent fisheries differ substantially from those prior to 1993. Data from the Canadian otter trawl fishery in the first quarter were examined. Although peak length groups are similar during both periods, there is a substantial reduction in the numbers of larger fish seen in the data after the mid 1990's (Fig. 6). There has been a reduction in the length of the largest fish, both male and female, observed in the commercial catches since the early 1990's, with the largest fish seen in 1997-98 being 15-20 cm smaller than the largest fish seen in the mid 1980's (Fig. 7). There was an increase in the percentage of females in the catches from around 70% in 1983-93 to over 85% in 1994-98 (Fig. 8). The available data show length compositions after 1993 were much different than those observed previously.

Data from the 1997 and 1998 Canadian otter trawl fisheries carried out in the first quarter were similar, although the 1998 length composition was shifted slightly toward smaller fish (Fig. 9). In 1998, some data were available from Canadian vessels fishing under quotas assigned to France, and length compositions from these two Canadian components were similar (Fig. 10).

In summary, there have been major changes in the commercial fisheries and the resulting length compositions taken from these fisheries on this stock during the 1990's. There has been a substantial truncation of the length distribution since the early to mid 1990's, and length frequencies since then have usually been comprised of about 90% females. Thus it is not advisable to apply historic length and age compositions to the recent catch data. Minimal fixed gear sampling is available, although these gears took the majority of catches since 1992. No otolith readings are available for the commercial fishery on this stock since 1993. For these reasons, it is not possible to construct representative catch at age from this stock for the years 1993-98 with available data.

Research Vessel Surveys

Stratified-random surveys have been conducted by Canada in Subdivision 3Ps in each year from 1972 to 1999, based on the stratification scheme shown in Figure 11. There were two surveys in 1993, one in February and one in April. Most of the surveys prior to 1993 were in February/March, while those since 1993 have been in April. The data can be split into three time periods based on the trawl used in each period: 1971-82 was Yankee 36, 1983-95 was Engel 145 and 1996-99 was Campelen 1800 (see McCallum and Walsh (1996) for a description of the various trawls).

Data Conversion

Conversions exist for the Yankee 36 to Engel 145 trawls based on Gavaris and Brodie (1984). Conversions from the Engel 145 to Campelen 1800 are presented here. There is presently no conversion from the Yankee 36 to Campelen 1800.

Conversions of the Engel 145 length frequencies to Campelen 1800 length frequencies followed Morgan et al. (1998). The conversion used is as follows (for fish of length X):

for 24 cm $\leq$ X $\leq$ 39 cm conversion factor: $\ln(y) = 39.958 + 0.358[X - 41 \ln(X)]$
for 23 cm $\leq$ X the conversion factor would be 10.02
for 40 cm $\geq$ X the conversion factor would be 1.0.

After the length frequencies were converted to Campelen trawl catch equivalents they were used in the standard stratified analysis program, along with annual age-length keys collected for each sex. This provided total numbers of American plaice caught, by length and age group, per standard Campelen set (0.8 nautical mile tow distance in 15 minutes with a wing spread of 16.84 m). In a separate analysis, the length-weight relationships (given in Table 2) were applied to the converted abundance at length values to obtain biomass at length, and then summed over all lengths to get total estimated biomass in Campelen equivalents.

Abundance at length for Engel and Campelen equivalent data from 1983-95 is given in Fig 12. The large increase in smaller fish in the converted data is easily seen. When age length keys are applied to the converted data, the age compositions are shifted toward younger fish (Tables 3 and 4).

Trends in Biomass and Abundance

Biomass and abundance indices from 1972-99 are shown in Figure 13. Mean number and weight per stratum for 1996-99 are given in Tables 5 and 6. Both biomass and abundance were variable from 1973-83 with perhaps a slight increasing trend. From the mid 1980's to 1990 there was a large decline in the indices. Since 1992 stock size has been very low. There has been a slight increase since 1993 in both biomass and abundance indices but current biomass is only 16% and abundance 21% of the 1983-87 average.

Abundance at age from 1983-98 is given in Table 4. Ageing is not completed for 1999. Abundance at all ages is low compared to the mid 1980's. The percentage of age 6+ fish has increased from 1996 to a level similar to the earlier part of the time series. The percentage of 9+ fish increased sharply in 1998 compared to 1996 and 1997.

American plaice are distributed throughout Subdivision 3Ps (Fig. 14 & 15). The 1972-94 time series of distribution plots is given in Bowering et al. (1996). From 1990-94 many survey sets with the Engel trawl caught no American plaice over the central and eastern portions of the St. Pierre Bank where they had previously been abundant. In contrast, surveys conducted with the Campelen trawl had few sets containing no American plaice. Similar to the 1990-94 period most of the larger catches were from the southeast slope of the St. Pierre Bank.

Mortality

Estimates of total mortality (Z) from the Campelen or equivalent survey data were calculated for ages 2 to 17 (Fig. 16). A Lowess smoother has been added to the plots to help visualize trends. For most ages mortality increased until the early to mid 1990's before declining in recent years. The average Z on ages 6-13 in 1994-95 was –1.0, despite very low catches. High mortality rates during a moratorium period with very low catches has also been found for the American plaice stock in Divisions 3LNO (Morgan et al. 1999).

Mean Length and Weight at Age

Mean lengths and weights at age by sex were calculated from survey data for 1983-98 and 1990-98 respectively. Means were calculated accounting for the length stratified sampling design. The results are presented in Figures 17 and 18. There is some indication of an increasing trend in both mean length and mean weight at age in the 1990's. The effect of year on mean length and weight at age was tested in two way analyses of variance including an age and year effect. There was a significant difference in mean length over the time period for both males ($F_{15,187}$=10.17, $p<0.0001$) and females ($F_{15,256}$=12.45, $p<0.0001$). There was also a significant difference in mean weight over the time period for males ($F_{8,94}$=3.52, $p<0.001$) and females ($F_{8,124}$=4.64, $p<0.0001$).

Maturities

Age and length at 50% maturity were estimated from survey data. Estimates of proportion mature at each age were also produced for use in spawning stock biomass calculations. Proportion mature at age was calculated according to the method of Morgan and Hoenig (1997) accounting for the length stratified sampling design and using Campelen or equivalent data.

A_{50} for both males and females has declined over the 1983-98 time period but this decline was not significant (Cox Stuart test for trends, Fig. 19). Bowering et al. (1996) found that there was a significant decline in A_{50} for both sexes over the 1973-93 period. The current A_{50} for males is 3.8 years and for females 8.7 years.

Estimates of maturity at length are not affected by the conversion of Engel data to Campelen equivalents. Therefore an entire time series from 1973 to 1998 is presented (Fig. 19). L_{50} for both sexes has been declining over most of the time period and this trend is

significant for both sexes (Cox Stuart test for trends, $p<0.001$). The current L_{50} for males is 16 cm compared to 29 cm at the beginning of the time series and for females it is 36 cm compared to 41 cm.

Spawning Stock Biomass

Female spawning stock biomass (SSB) was calculated using survey data from 1983 to 1998. The estimates of maturity and mean weight at age described above were used, along with female abundance at age. Before 1990 individual weights were not available and a length-weight relationship used in the conversion of biomass for that period (Table 2) was applied to mean length at age to produce mean weight at age. SSB calculated in a similar fashion for the Engel data was taken from Morgan et al. (1995).

SSB showed an increase from the mid 1970's to mid 1980's followed by a precipitous decline (Fig. 20). This rapid decline is seen in both the original Engel and the Campelen equivalent time series. Since 1993, SSB calculated from the Campelen series has been only 15% of the 1986-87 average. The 1998 index of female SSB is 7,000 t.

Recruitment

Cohort strengths were estimated using the following model using Engel data from 1973-95 and then with Campelen or equivalent data from 1983 to 1998:

$$\log(N_{ajt}) = \tau + \alpha_a + \delta_j + \varepsilon$$

where: N_{ajt} = number at age a belonging to cohort j in year t

τ = intercept

α_a = age effect for ages a=2...5

δ_j = cohort effect

ε =residuals from the fitted model

For the Engel time series this model gave a significant fit to the data and there was a significant cohort effect.

R^2=0.88, n=62

Source	DF	Type III SS	F value	Pr>F
AGE	3	102.75	50.01	0.0001
COHORT	20	73.02	5.33	0.0001

For the Campelen time series there was also a significant fit of the model to the data but there was no significant cohort effect.

R^2=0.77, n=53

Source	DF	Type III SS	F value	Pr>F
AGE	3	99.06	26.79	0.0001
COHORT	18	35.60	1.60	0.12

The results of these models are shown in Figure 21. The Engel time series shows no good year classes from 1980-92. The largest year classes were 1977 and 1978. The Campelen time series also shows the 1978 year class to be above average and also indicates that the 1994 year class may be stronger than average. Consistent with the Engel series, there was no sign of good recruitment from 1980-92.

These two sets of relative cohort strength are plotted against their respective indices of SSB in Figure 22. Both series indicate that some of the best year classes arise from some of the lowest SSBs.

No ageing was available from 1999. To examine this data for signs of recruitment the percent at length from the survey indices of population abundance were plotted for 1997-99 (Fig. 23). There is a slightly higher percentage of fish less than 10 cm (1-2 year olds) in 1999 but no clear indication of a large year class.

Catch to Survey Biomass

As a proxy for exploitation rate on this stock, the ratio of catch to biomass from spring research vessel surveys was examined from Campelen data from 1983 to 1998 (Fig. 24). Catch/biomass ratio increased steadily through the 1980's reaching a peak of 0.31 in 1990. Since 1994 the C/B ratio has been less than 0.05, reflecting the low catch levels. This maximum is much higher than that calculated for the adjacent Div. 3LNO stock which peaked at 0.13 (in 1991, Morgan et al., 1999). The biomass in the 1990 survey of 3Ps was low compared to 1989 and 1991. This may have artificially inflated the estimate of the C/B ratio in that year. If the biomass in 1990 is estimated to be between those of the adjacent years then the C/B ratios in that year would be 0.14. The assessment of the Div. 3LNO stock indicates that the index derived from the Campelen trawl is actually an overestimate of stock size. If this is the case then the C/B ratios would in general underestimate exploitation.

Assessment

Indices of abundance and biomass showed a large decline from the mid 1980's to 1990. Since 1992 stock size has been very low. There has been a slight increase since 1993 in both biomass and abundance indices but current biomass is only 16% and abundance 21% of the 1983-87 average. The 1994 year class may be above average but

there are no other year classes since 1980 that have been larger than average. For most ages mortality increased until the early to mid 1990's before declining in recent years. The average Z on ages 6-13 in 1994-95 was –1.0, despite very low catches. Given the current low stock size and the lack of recruitment indicated by the surveys and the slow growing nature of American plaice there is little prospect of significant rebuilding in the short to medium term.

References

Bowering, W.R., W.B. Brodie, and M.J. Morgan. 1996. Changes in abundance and certain population parameters of American plaice on St. Pierre Bank off Newfoundland during 1972-1994, with implications for fisheries management. N. Amer. J. Fish. Manag. 16:747-769.

Brodie, W.B. 1991. An assessment of the American plaice stock in NAFO Subdivision 3Ps. CAFSAC Res. Doc. 91/72.

Gavaris, S. and W.B. Brodie. 1984. Results of comparative fishing between the *A.T. Cameron* and the *Wilfred Templeman* during July-August 1983. CAFSAC Res. Doc. 84/41.

McCallum, B.R. and S.J. Walsh. 1996. Groundfish Survey trawls used at the Northwest Atlantic Fisheries Centre, 1971-present. NAFO SCR Doc. 96/50.

Morgan, M. J., and J. M. Hoenig. 1997. Estimating maturity-at-age from length stratified sampling. J. Northw. Atl. Fish. Sci., **21**: 51-63.

Morgan, M.J., W.B. Brodie, and G.T. Evans. 1995. Assessment of the American plaice stock in NAFO Subdiv. 3Ps. DFO Atlantic Fisheries Research Document 95/36.

Morgan, M.J., W.B. Brodie, and W.R. Bowering. 1999. An assessment of American plaice in NAFO Div. 3LNO. NAFO SCR Doc. 99/44.

Morgan, M.J., W.B. Brodie, W.R. Bowering, D.Maddock Parsons, and D.C. Orr. 1998. Results of Data Conversions for American plaice in Div. 3LNO from Comparative Fishing Trials between the Engel Otter Trawl and the Campelen 1800 Shrimp Trawl. NAFO SCR Doc. 98/70.

Table 1. Catches (1960-98) and TACs (1974-99) of American plaice in NAFO Subdivision 3Ps. All values in metric tons.

Year	Canada			France	USSR	Other	Total	TAC
	Nfld	M&Q	Total					
1960	422	405	827	60	-	-	887	-
1961	764	660	1,424	31	-	-	1,455	-
1962	659	363	1,022	2	-	-	1,024	-
1963	504	25	529	208	1	16	754	-
1964	1,132	230	1,362	152	-	28	1,542	-
1965	574	1,275	1,849	162	-	11	2,022	-
1966	1,162	1,332	2,494	667	218	27	3,406	-
1967	2,201	1,074	3,275	533	678	8	4,494	-
1968	4,007	1,516	5,523	524	8,233	-	14,280	-
1969	2,888	1,178	4,066	245	2,180	-	6,491	-
1970	7,368	4,227	11,595	397	336	-	12,328	-
1971	4,667	1,286	5,953	820	409	-	7,182	-
1972	4,301	1,621	5,922	383	220	13	6,538	-
1973	10,972	1,840	12,812	547	1,368	42	14,769	-
1974	5,887	443	6,330	268	-	-	6,598	11,000
1975	2,517	1,301	3,818	65	128	200	4,211	11,000
1976	5,302	128	5,430	5	9	14	5,458	8,000
1977	4,235	307	4,542	63	-	-	4,605	6,000
1978	3,419	192	3,611	47	-	-	3,658	4,000
1979	3,405	187	3,592	74	-	-	3,666	4,000
1980	2,516	213	2,729	206	-	-	2,935	5,000
1981	2,703	57	2,760	457	-	-	3,217	5,000
1982	1,823	46	1,869	317	-	-	2,186	5,000
1983	1,421	83	1,504	222	-	-	1,726	5,000
1984	2,487	138	2,625	338	-	-	2,963	5,000
1985	3,608	206	3,814	406	-	-	4,220	5,000
1986	4,367	98	4,465	665	-	-	5,130	5,000
1987	4,669	119	4,788	543	-	-	5,331	5,000
1988	3,745	56	3,801	605	-	-	4,406	5,000
1989	3,102	96	3,198	759	-	-	3,957	5,000
1990	3,880	226	4,106	739	-	-	4,845	4,000
1991	3,982	76	4,058	337	-	-	4,395	4,000
1992	2,380	290	2,670	9	-	-	2,679	4,000
1993[a]	723	57	780	-	-	-	780	3,000
1994[a]	112	11	123	-	-	-	123	500[b]
1995[a]	80	10	90	-	-	-	90	100[b]
1996[a]	112	3	115	-	-	-	115	100[b]
1997[a]	213	7	220	23	-	-	243	100[b]
1998[a]	405	2	407	16	-	-	423	0
1999								0

[a]Provisional
[b]By-catch

Table 2. Canadian catch of American plaice in Subdivision 3Ps by gear type for 1985 to 1998.

Gear/Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
otter trawl	3406.71	3183.26	2767.06	2458.47	1883.87	2985.19	2791.81	1556.29	262.28	65.22	28.9	50.32	100.39	126.57
gillnet	108.36	893.35	1631.2	1099.8	1054.62	737.87	978	568.76	352.62	41.55	42.29	62.15	83.82	174.3
longline	274.71	341.72	305.78	219.39	195.2	285.2	190.9	134.13	44.31	0.07	0.03	0.08	26.22	97.98
seine	1.6	10.23	3.5	2.04	6.49	13.04	10.82	11.8	18.9	12.22	10.91	0.87	0.95	5.1
other	33.1	27.49	64.91	27.79	40.22	84.9	14.9	20.08	15.87	2.46	0	0.49	8.93	2.72

Table 3. Length weight relationships used in the conversion of Engel to Campelen biomass. These relationships were applied to the converted number at age. Logwt= log weight in kilograms and loglen= log length in centimeters.

Year	Equation
1983-89	Logwt=(3.233*loglen)-5.434
1990	Logwt=(3.457*loglen)-5.801
1991	Logwt=(3.180*loglen)-5.337
1992	Logwt=(3.247*loglen)-5.452
1993	Logwt=(3.377*loglen)-5.662
1994	Logwt=(3.356*loglen)-5.637
1995	Logwt=(3.397*loglen)-5.702

Table 4. Abundance index (millions) at age for A. plaice in Subdiv. 3Ps from Canadian research vessel surveys. Data are original Engel estimates.

age/year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993 Feb	1993 Apr	1994	1995
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0.01	0	0	0	0	0	0.01	0.04	0.01	0	0	0.01	0
3	0.16	0	0.02	0.05	0.12	0.07	0.11	0.02	0.15	0.02	0.02	0	0.01	0
4	1.2	0.19	0.42	0.64	0.38	0.46	0.47	0.20	0.34	0.06	0.02	0.00	0.33	0.07
5	7.12	1.95	2.74	2.18	1.95	2.48	1.23	0.79	1.34	0.59	0.07	0.23	0.55	0.53
6	16.65	7.56	7.63	8.71	5.52	8	3.74	0.87	2.74	1.46	0.54	1.22	1.27	1.16
7	19.61	9.03	14.5	15.21	11.87	10.3	6.03	1.41	4.07	2.66	1.15	2.13	2.16	2.62
8	18.78	8.15	10.35	10.68	14.89	13.76	4.85	1.58	5.33	1.65	1.05	1.93	2.06	2.75
9	16.01	6.57	10.48	5.88	9.66	7.35	4.49	1.63	4.16	1.58	0.85	1.55	1.52	2.28
10	7.99	5.44	9.39	4.68	6.86	4.59	2.54	1.23	3.05	1.26	0.64	1.03	0.87	1.10
11	5.15	2.99	5.61	2.71	3.19	1.95	1.64	0.75	1.34	0.72	0.36	0.52	0.49	0.53
12	2.72	1.67	3.89	2.26	2.8	1.36	1.49	0.46	1.12	0.51	0.16	0.37	0.16	0.19
13	1.74	0.7	3.81	1.67	1.77	0.75	1.03	0.19	0.74	0.52	0.10	0.26	0.07	0.10
14	1.06	0.49	2.62	0.89	1.13	0.59	0.59	0.21	0.37	0.23	0.06	0.14	0.02	0.05
15	0.67	0.34	2.53	0.94	0.99	0.54	0.38	0.21	0.47	0.4	0.04	0.11	0	0.01
16	0.7	0.15	2.14	0.62	0.67	0.31	0.46	0.16	0.4	0.18	0.03	0.09	0	0
17	0.22	0.11	1.17	0.24	0.22	0.25	0.19	0.10	0.11	0.08	0.02	0.04	0	0
18	0.13	0.08	1.29	0.18	0.14	0.03	0.13	0.08	0.03	0.04	0.01	0.01	0	0
19	0.11	0.01	0.07	0.03	0.03	0.01	0.05	0.03	0.01	0.01	0	0.01	0	0
Total	100.02	45.44	78.66	57.57	62.19	52.8	29.42	9.94	25.81	11.98	5.10	9.64	9.50	11.40

Table 5. Abundance index (millions) at age for A. plaice in Subdiv. 3Ps from Canadian research vessel surveys. Data from 1983 to 1995 are Campelen equivalents.

age/year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993 Feb	1993 Apr	1994	1995	1996	1997	1998
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02
2	0.12	0.27	0.00	0.00	0.00	0.00	0.00	0.11	0.71	0.14	0.00	0.00	0.23	0.00	4.67	0.37	0.60
3	2.84	0.00	0.48	1.02	2.14	1.21	1.98	0.36	2.82	0.40	0.32	0.00	0.19	0.00	11.94	7.22	0.62
4	22.02	3.36	7.59	11.80	6.23	7.60	8.59	3.71	5.75	1.02	0.44	0.06	3.23	0.47	20.54	8.73	6.19
5	101.96	31.20	40.16	34.27	32.45	32.44	18.77	11.97	22.55	8.26	0.78	3.07	7.38	4.95	24.91	7.96	8.78
6	142.59	78.99	81.77	90.21	67.65	61.67	39.89	10.37	40.00	14.96	6.21	12.07	9.99	11.72	11.54	7.37	6.12
7	112.32	46.34	73.58	84.66	75.07	42.40	39.95	9.31	33.97	14.12	6.87	11.35	9.02	14.94	10.90	7.36	10.31
8	63.09	21.66	26.51	32.29	50.28	35.73	14.56	6.17	26.62	4.88	3.48	6.86	6.73	8.67	3.92	3.62	7.16
9	35.25	13.19	21.71	12.94	21.92	15.24	9.82	3.84	11.37	3.42	1.72	3.28	3.42	5.24	2.14	1.62	6.27
10	15.57	10.09	17.57	8.73	13.24	8.57	4.73	2.42	6.45	2.38	1.19	1.99	1.79	2.04	0.80	0.53	2.88
11	9.71	5.45	10.35	4.96	5.83	3.57	3.00	1.37	2.57	1.36	0.65	0.95	0.91	0.97	0.32	0.24	1.69
12	4.98	3.06	7.12	4.13	5.12	2.50	2.74	0.84	2.05	0.93	0.29	0.67	0.29	0.36	0.17	0.20	0.97
13	3.19	1.27	6.97	3.06	3.24	1.37	1.88	0.35	1.35	0.94	0.18	0.48	0.12	0.18	0.02	0.09	0.56
14	1.95	0.91	4.79	1.64	2.04	1.09	1.08	0.39	0.69	0.43	0.11	0.26	0.03	0.10	0.02	0.10	0.15
15	1.23	0.62	4.64	1.72	1.83	0.98	0.69	0.39	0.86	0.72	0.07	0.21	0.00	0.01	0.03	0.01	0.15
16	1.29	0.28	3.91	1.14	1.22	0.58	0.85	0.30	0.73	0.33	0.06	0.16	0.00	0.00	0.00	0.00	0.10
17	0.41	0.20	2.12	0.42	0.40	0.45	0.35	0.19	0.21	0.15	0.03	0.07	0.00	0.00	0.00	0.00	0.06
18	0.25	0.14	2.34	0.33	0.27	0.05	0.23	0.15	0.05	0.07	0.01	0.03	0.00	0.00	0.00	0.00	0.00
19	0.19	0.02	0.14	0.06	0.05	0.03	0.09	0.05	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UNKNOWN	0.00	0.27	1.04	0.00	0.00	0.00	0.02	0.00	0.18	0.11	0.15	0.00	0.01	0.13	0.15	0.01	0.00
TOTAL	518.96	217.33	312.85	293.38	288.98	215.50	149.23	52.30	158.98	54.64	22.57	41.54	43.34	49.77	92.09	45.46	52.62

Table 6. Mean number per tow and number of sets by stratum from Canadian RV surveys in Subdivision 3Ps from 1996 to 1999.

		Year	1996		1997		1998		1999	
Depth range	Stratum	Units	Number	Sets	Number	Sets	Number	Sets	Number	Sets
<=56	314	133984	2.00	8	0.14	7	5.51	7	15.19	8
	320	181581	14.43	10	0.67	9	9.64	11	19.63	8
57 - 91	293	21872	-	-	0.44	2	0.89	2	2.00	2
	308	15407	2.00	2	2.00	2	1.00	2	33.00	2
	312	37417	15.33	3	0.50	2	9.33	2	11.89	2
	315	113763	61.57	6	5.00	6	41.86	7	38.24	7
	321	163560	11.67	9	13.91	9	7.30	10	23.63	9
	325	129858	10.38	9	50.17	6	23.86	8	52.01	8
	326	22835	12.50	2	5.00	2	11.00	2	22.33	2
	783	31501	-	-	0.00	2	0.44	2	1.00	2
93 - 183	294	18571	-	-	1.50	2	10.33	2	7.50	2
	297	20909	-	-	16.00	2	15.50	2	12.11	2
	307	54337	2.17	4	0.00	3	3.56	3	15.38	3
	311	43607	29.00	3	36.50	2	64.74	3	29.19	3
	317	26549	148.00	2	25.50	2	164.00	2	104.00	2
	319	135360	217.84	8	42.47	8	117.13	8	69.72	8
	322	215558	45.16	11	11.44	11	5.73	13	34.46	12
	323	95743	91.74	5	29.00	4	49.57	6	105.19	6
	324	67955	108.33	3	19.00	3	9.75	4	92.07	4
	781	61352	97.07	2	3.50	4	2.14	4	15.00	4
	782	25174	-	-	13.00	2	8.50	2	19.00	2
184 - 274	295	28750	-	-	42.11	2	43.67	2	37.11	2
	298	23523	-	-	11.50	2	8.44	2	4.00	2
	300	29851	-	-	1.33	2	5.33	2	6.50	2
	306	49935	5.82	3	5.00	3	3.05	3	6.41	3
	309	40718	6.26	3	2.72	2	9.33	2	1.00	2
	310	23385	8.50	2	7.11	2	22.39	2	6.50	2
	313	22698	15.56	2	4.50	2	31.11	2	5.50	2
	316	25999	34.00	2	67.00	2	41.00	2	1.69	2
	318	17745	36.50	2	49.50	2	45.50	2	9.14	2
	779	58051	62.67	3	10.00	3	8.00	3	32.06	4
	780	55437	-	-	11.56	3	4.67	3	22.70	3
275 - 366	296	9766.8	-	-	5.89	2	31.39	2	30.94	2
	299	29163	-	-	2.39	2	3.51	2	1.50	2
	705	26824	8.71	2	12.00	2	14.28	2	1.44	2
	706	65479	9.33	3	5.89	3	7.25	4	0.67	4
	707	10180	46.80	2	52.89	2	24.00	2	5.33	2
	715	17608	12.78	2	1.14	2	0.00	2	3.00	2
	716	74145	11.76	5	7.89	4	5.39	4	1.94	4
367 - 549	708	17333	59.50	2	626.89	2	23.70	3	0.44	2
	711	81574	3.92	4	0.60	5	0.78	5	0.16	5
	712	100557	2.00	6	3.60	5	1.76	6	1.32	6
	713	117064	2.98	7	4.82	6	3.57	7	2.95	7
	714	147741	3.99	9	3.64	7	4.19	9	4.86	9
550 - 731	709	20221	13.00	2	-	-	7.00	2	0.89	2
732 - 914	710	21460	-	-	-	-	-	-	0.00	2

Table 7. Mean weight per tow and number of sets by stratum for Canadian RV surveys in Subdivision 3Ps from 1996 to 1999.

		Year	1996		1997		1998		1999	
Depth range	Stratum	Units	Weight	Sets	Weight	Sets	Weight	Sets	Weight	Sets
<=56	314	133984	0.58	8	0.14	7	2.87	7	7.89	8
	320	181581	4.13	10	0.45	9	7.31	11	10.90	8
57 - 91	293	21872	-	-	0.01	2	0.08	2	0.67	2
	308	15407	0.80	2	0.19	2	0.14	2	12.35	2
	312	37417	1.62	3	0.03	2	1.64	2	6.40	2
	315	113763	15.03	6	1.55	6	13.85	7	9.74	7
	321	163560	2.27	9	1.33	9	1.45	10	7.88	9
	325	129858	1.89	9	2.80	6	3.50	8	5.79	8
	326	22835	2.53	2	0.55	2	2.15	2	2.16	2
	783	31501	-	-	0.00	2	0.04	2	0.23	2
93 - 183	294	18571	-	-	0.04	2	1.35	2	0.98	2
	297	20909	-	-	1.25	2	1.59	2	2.46	2
	307	54337	0.24	4	0.00	3	1.82	3	3.30	3
	311	43607	1.85	3	11.98	2	13.72	3	13.37	3
	317	26549	26.10	2	2.38	2	35.28	2	14.20	2
	319	135360	26.90	8	4.89	8	35.15	8	15.85	8
	322	215558	2.76	11	0.82	11	0.38	13	5.62	12
	323	95743	6.80	5	1.40	4	4.99	6	13.13	6
	324	67955	5.87	3	1.17	3	0.58	4	11.22	4
	781	61352	4.23	2	0.21	4	0.14	4	1.14	4
	782	25174	-	-	0.75	2	0.51	2	1.50	2
184 - 274	295	28750	-	-	5.13	2	5.46	2	6.64	2
	298	23523	-	-	2.33	2	3.44	2	0.93	2
	300	29851	-	-	0.40	2	1.63	2	0.60	2
	306	49935	0.76	3	0.63	3	0.29	3	1.52	3
	309	40718	1.43	3	0.66	2	1.89	2	0.06	2
	310	23385	2.50	2	3.26	2	10.22	2	2.95	2
	313	22698	3.91	2	2.18	2	12.69	2	1.60	2
	316	25999	12.75	2	38.68	2	28.80	2	0.70	2
	318	17745	10.13	2	12.62	2	15.78	2	2.43	2
	779	58051	6.15	3	1.15	3	1.05	3	3.97	4
	780	55437	-	-	0.72	3	0.43	3	2.58	3
275 - 366	296	9766.8	-	-	1.73	2	10.55	2	8.29	2
	299	29163	-	-	0.62	2	0.87	2	1.75	2
	705	26824	5.22	2	5.35	2	5.31	2	0.27	2
	706	65479	3.10	3	2.35	3	4.06	4	0.24	4
	707	10180	11.48	2	14.91	2	11.51	2	2.00	2
	715	17608	7.81	2	0.32	2	0.00	2	1.04	2
	716	74145	3.89	5	3.06	4	2.46	4	0.83	4
367 - 549	708	17333	22.15	2	189.67	2	6.59	3	0.38	2
	711	81574	0.83	4	0.04	5	0.06	5	0.01	5
	712	100557	0.50	6	0.79	5	0.17	6	0.35	6
	713	117064	0.76	7	1.08	6	0.39	7	0.32	7
	714	147741	0.58	9	0.90	7	0.69	9	0.50	9
550 - 731	709	20221	4.03	2	-	-	1.58	2	0.29	2
732 - 914	710	21460	-	-	-	-	-	-	0.00	2

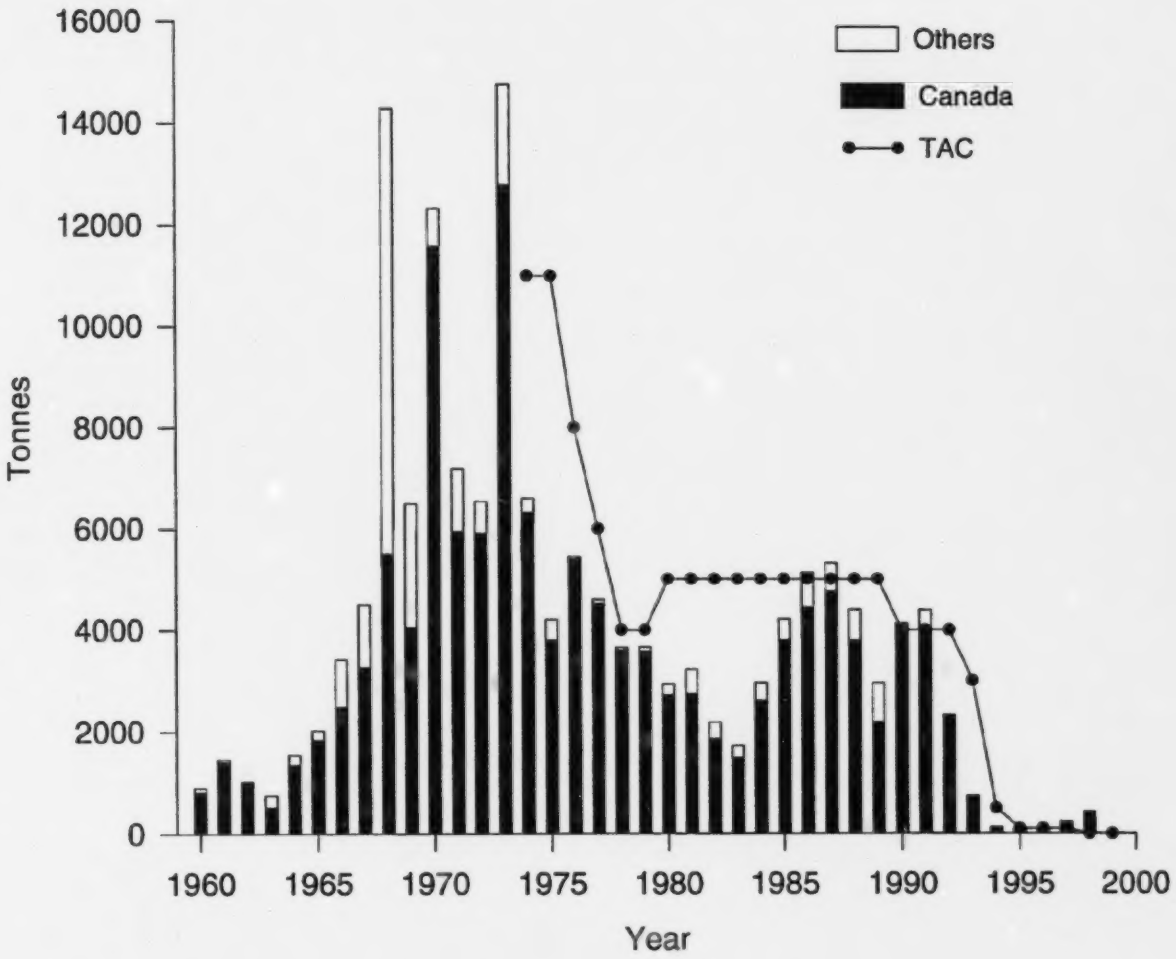

Figure 1. Total catch by Canada (black bars) and other countries (white bars) as well as the total allowable catch (TAC) for each year from 1960 to 1999.

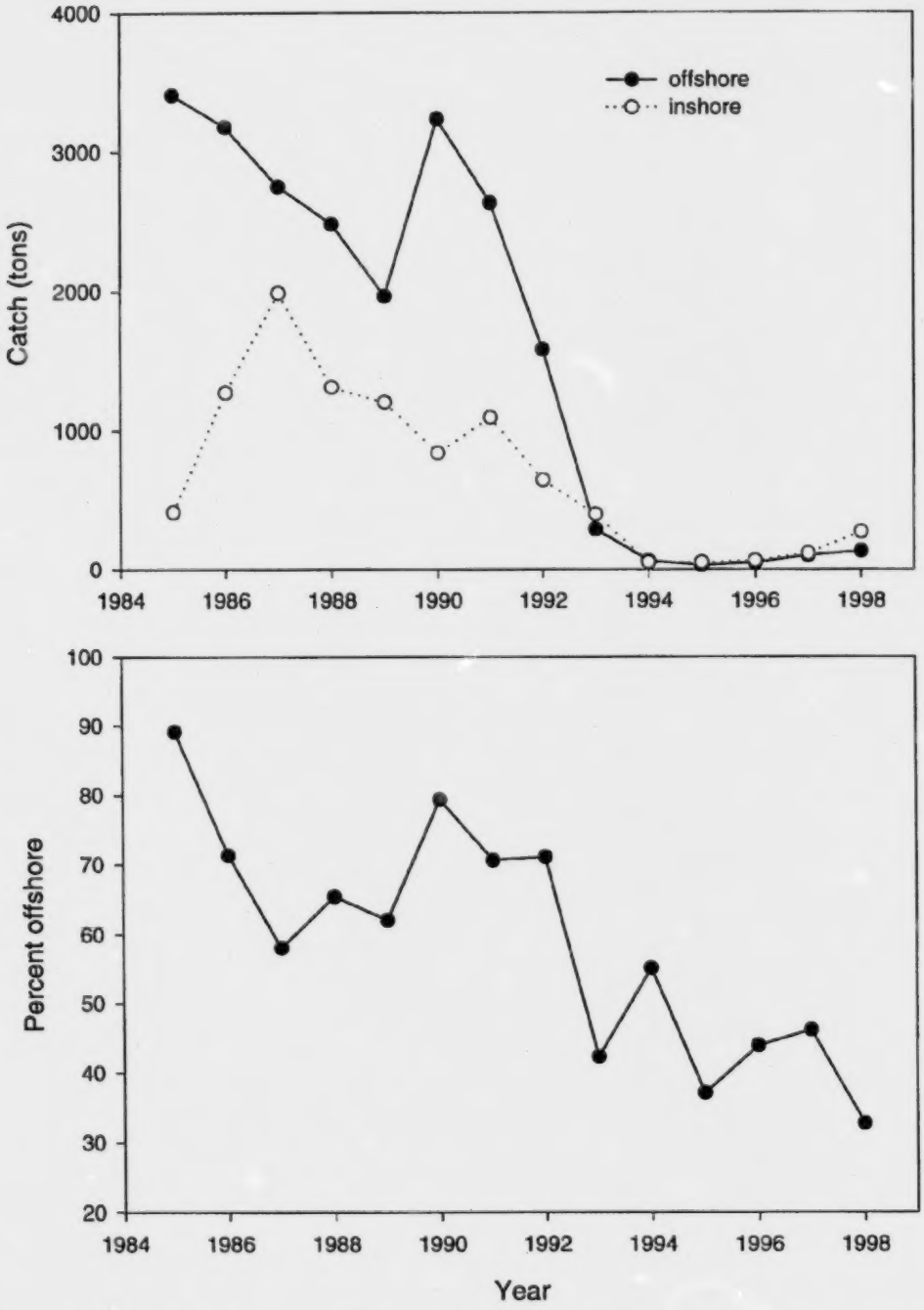

Figure 2. Canadian catch of American plaice in Subdivision 3Ps taken in the offshore and inshore fisheries from 1985-98. The percentage taken in the offshore fishery is also shown.

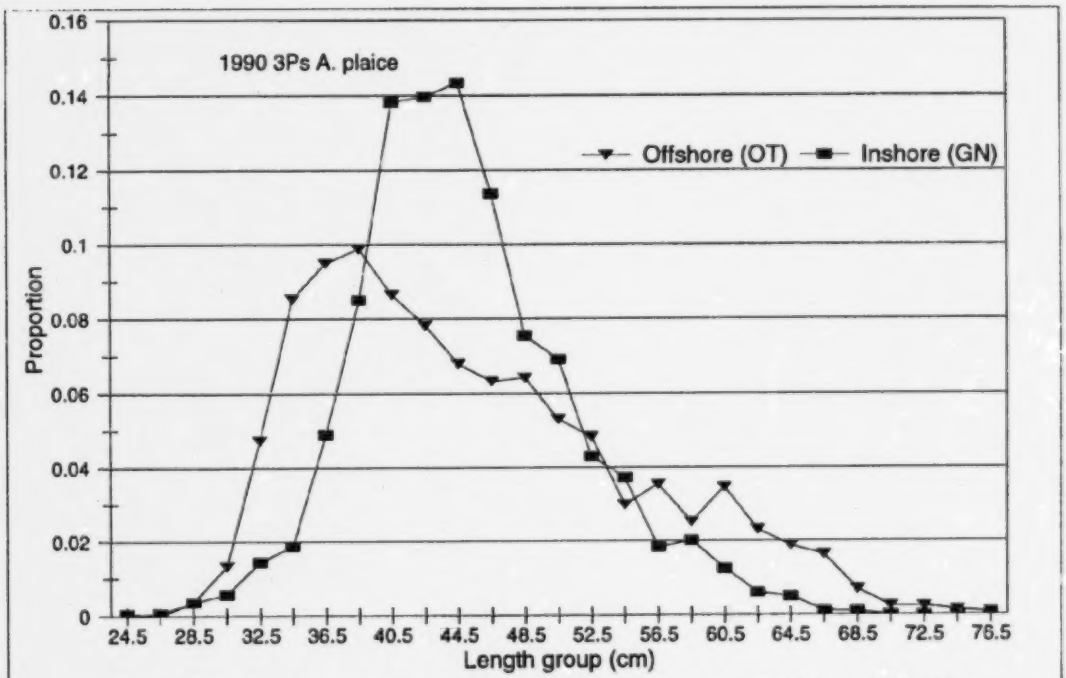

Fig. 3 . Comparison of proportions at length from the 1990 commercial fishery for A.plaice in Subdiv. 3Ps.

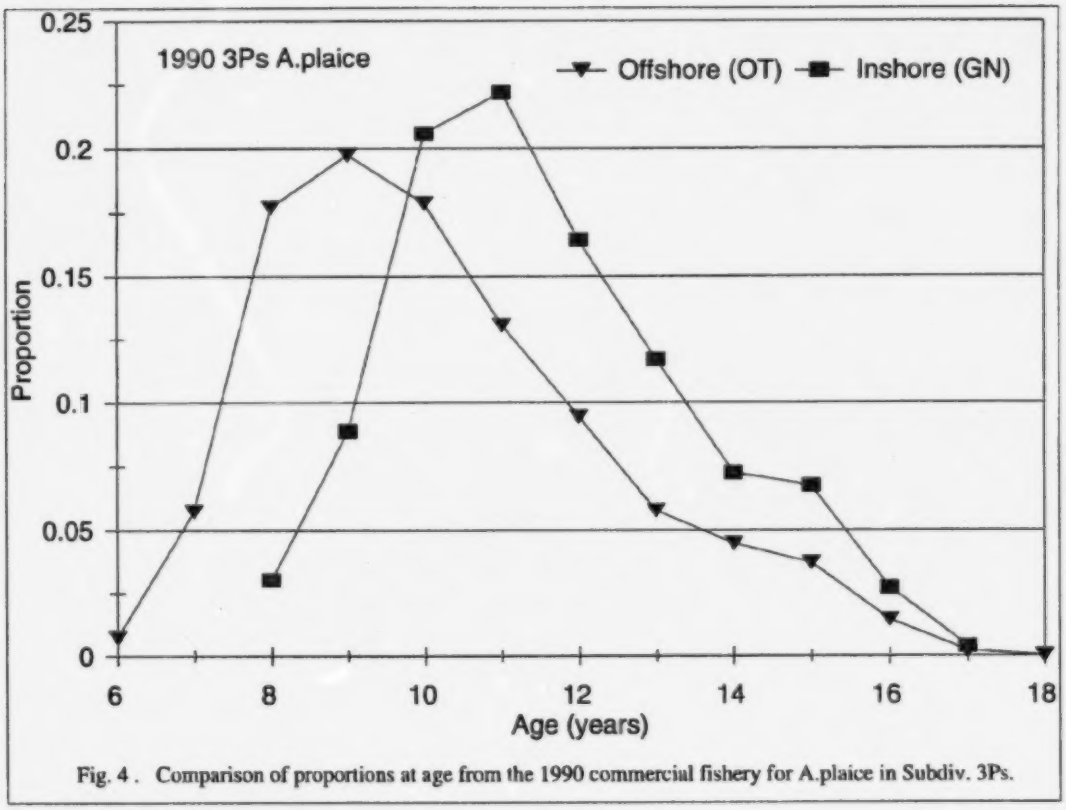

Fig. 4 . Comparison of proportions at age from the 1990 commercial fishery for A.plaice in Subdiv. 3Ps.

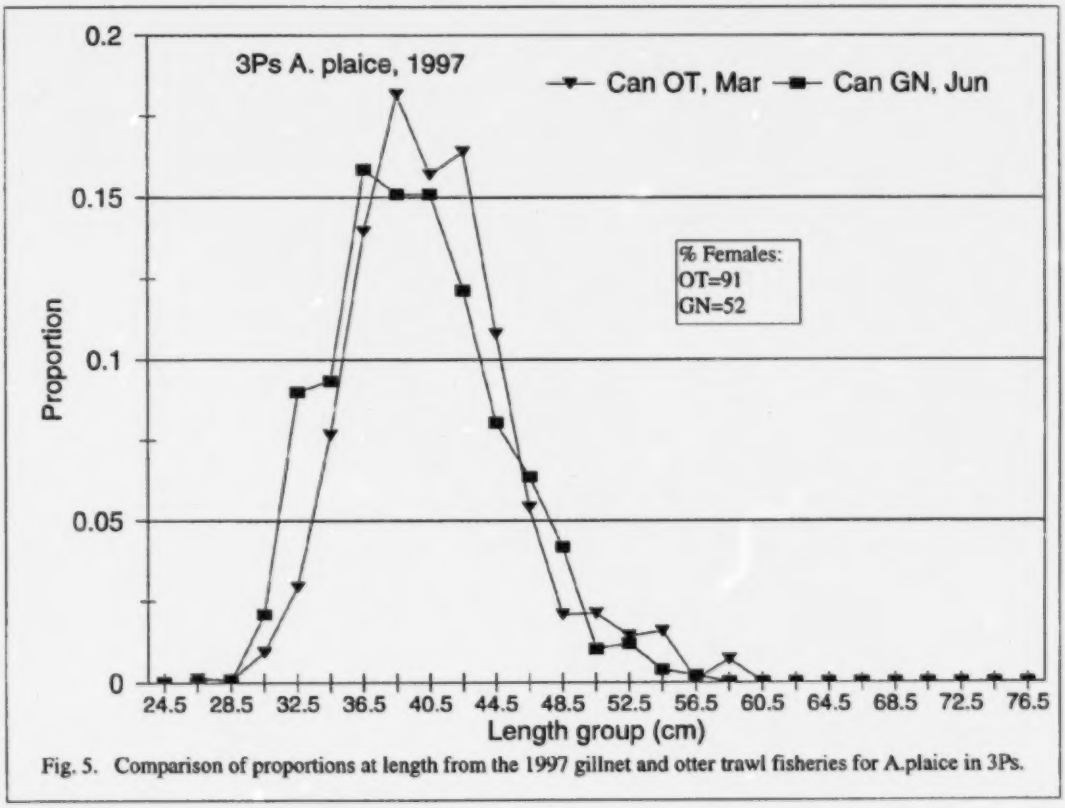

Fig. 5. Comparison of proportions at length from the 1997 gillnet and otter trawl fisheries for A.plaice in 3Ps.

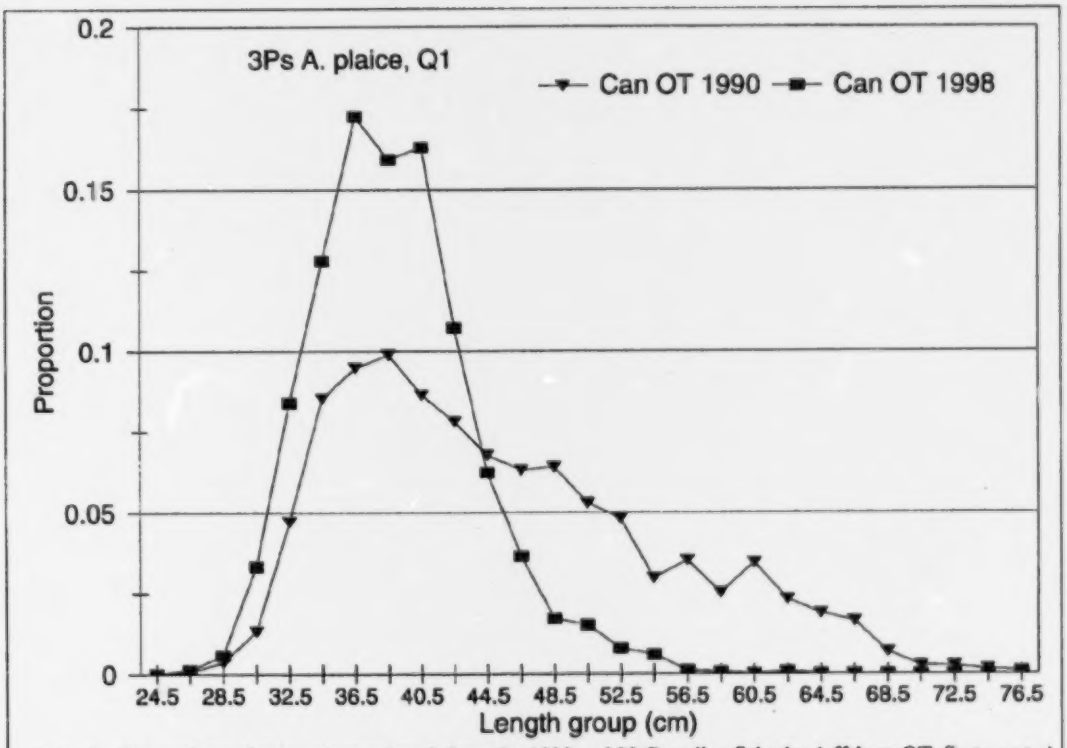

Fig. 6. Comparison of proportions at length from the 1990 and 98 Canadian fisheries (offshore OT, first quarter) for A.plaice in 3Ps.

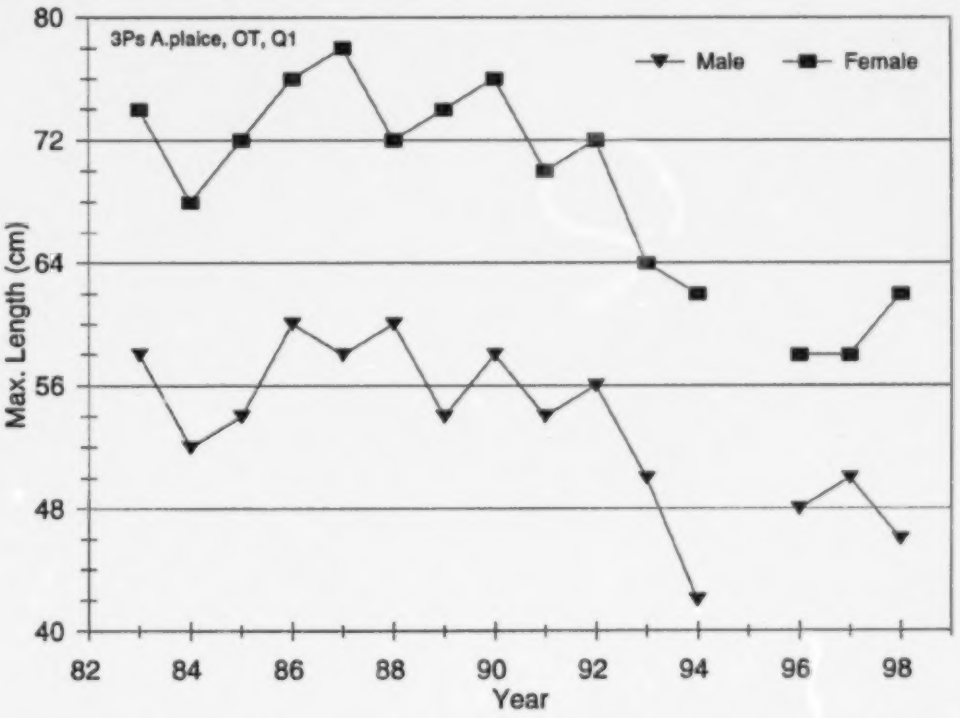

Fig 7. Maximum size of A. plaice in length frequencies from Canadian otter trawl fisheries in Subdiv 3Ps, 1983-98.

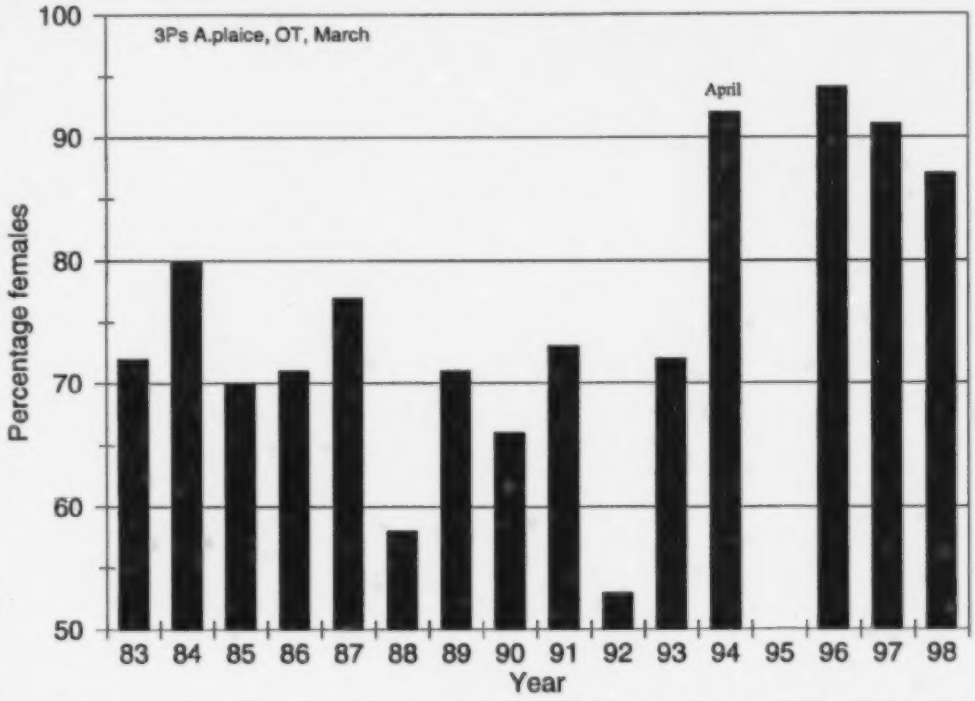

Fig. 8. Percentage of female A. plaice in length frequencies from Canadian OT fishery in Subdiv 3Ps, 1983-98.

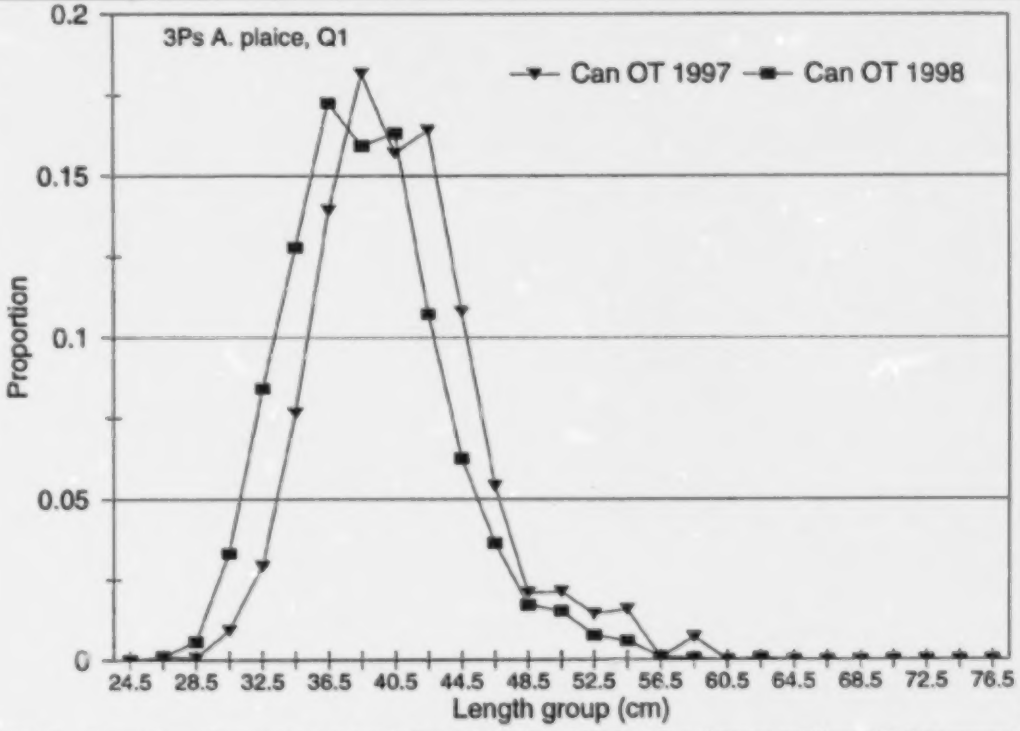

Fig. 9. Comparison of proportions at length from the 1997 and 98 Canadian fisheries (offshore OT, first quarter) for A.plaice in 3Ps.

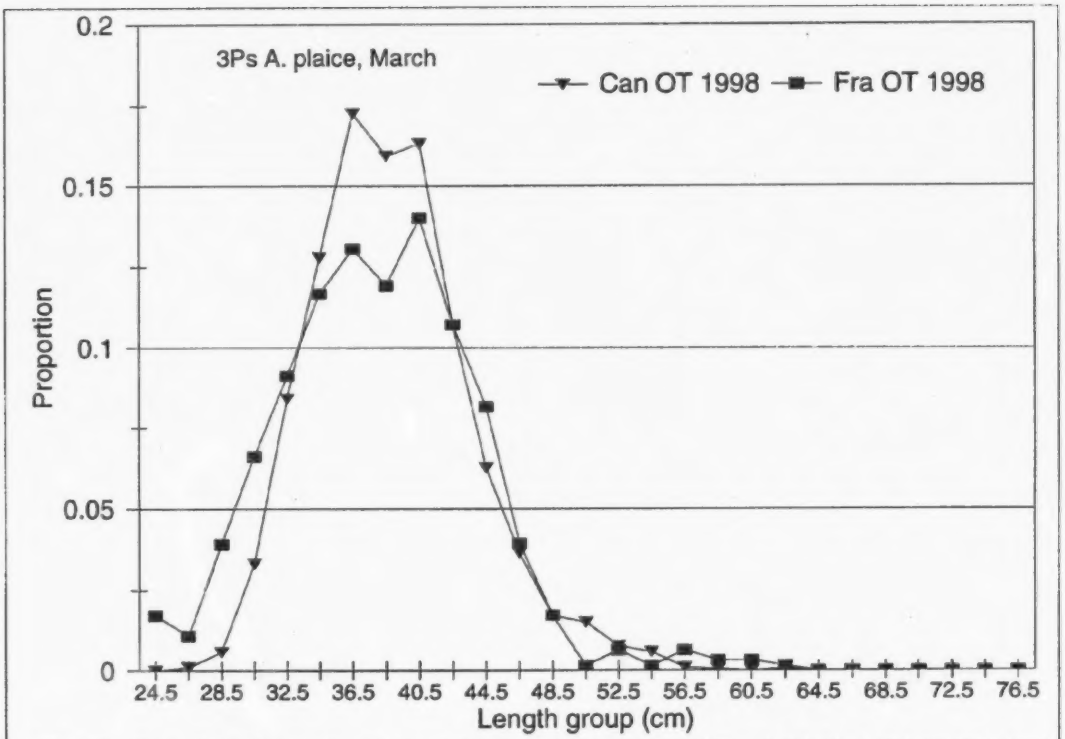

Fig. 10. Comparison of proportions at length from the 1998 Canadian and French fisheries (offshore OT, March) for A.plaice in 3Ps.

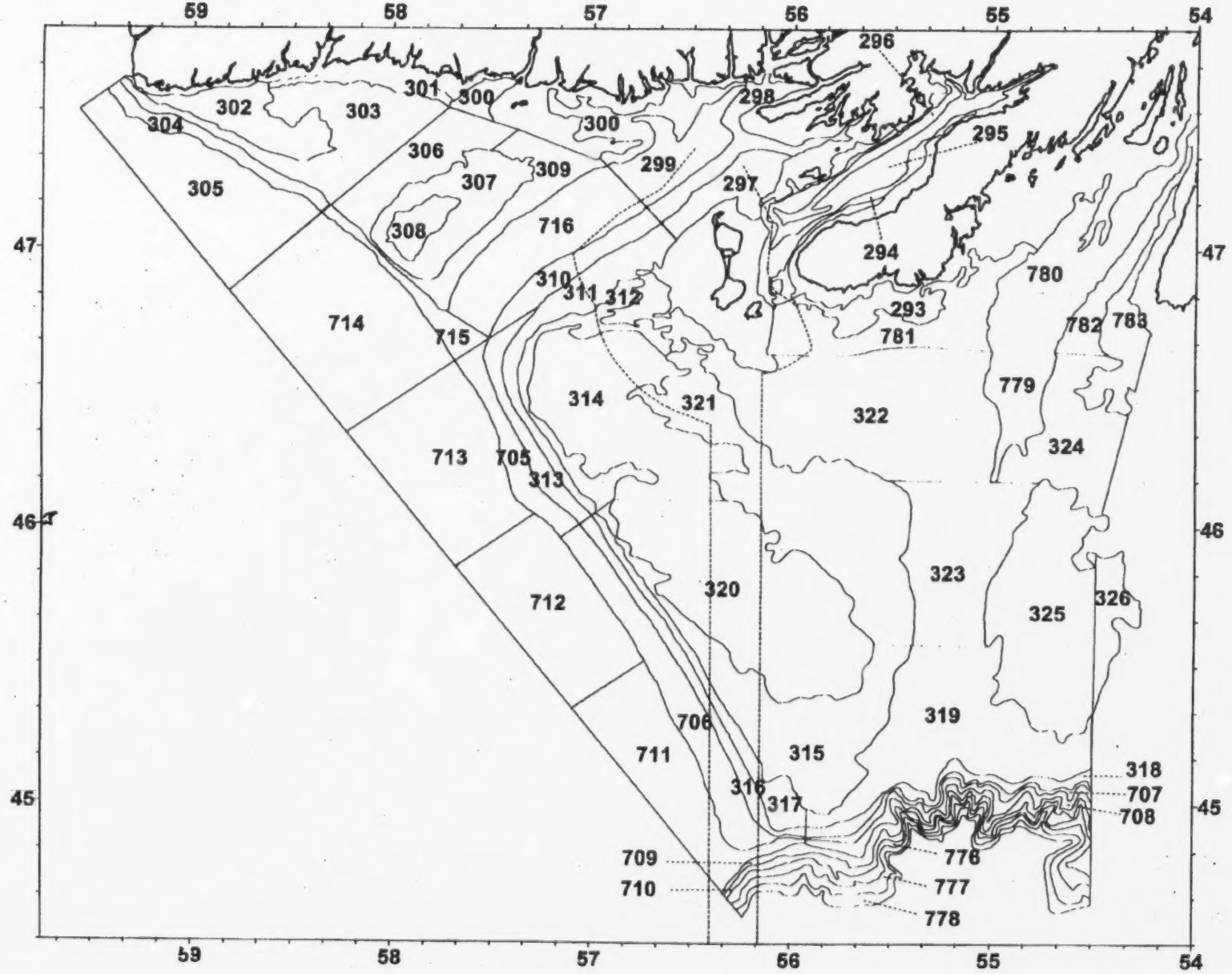

Fig 11 The survey area in NAFO Div. 3P showing strata boundaries currently in use in the spring research vessel bottom trawl survey.

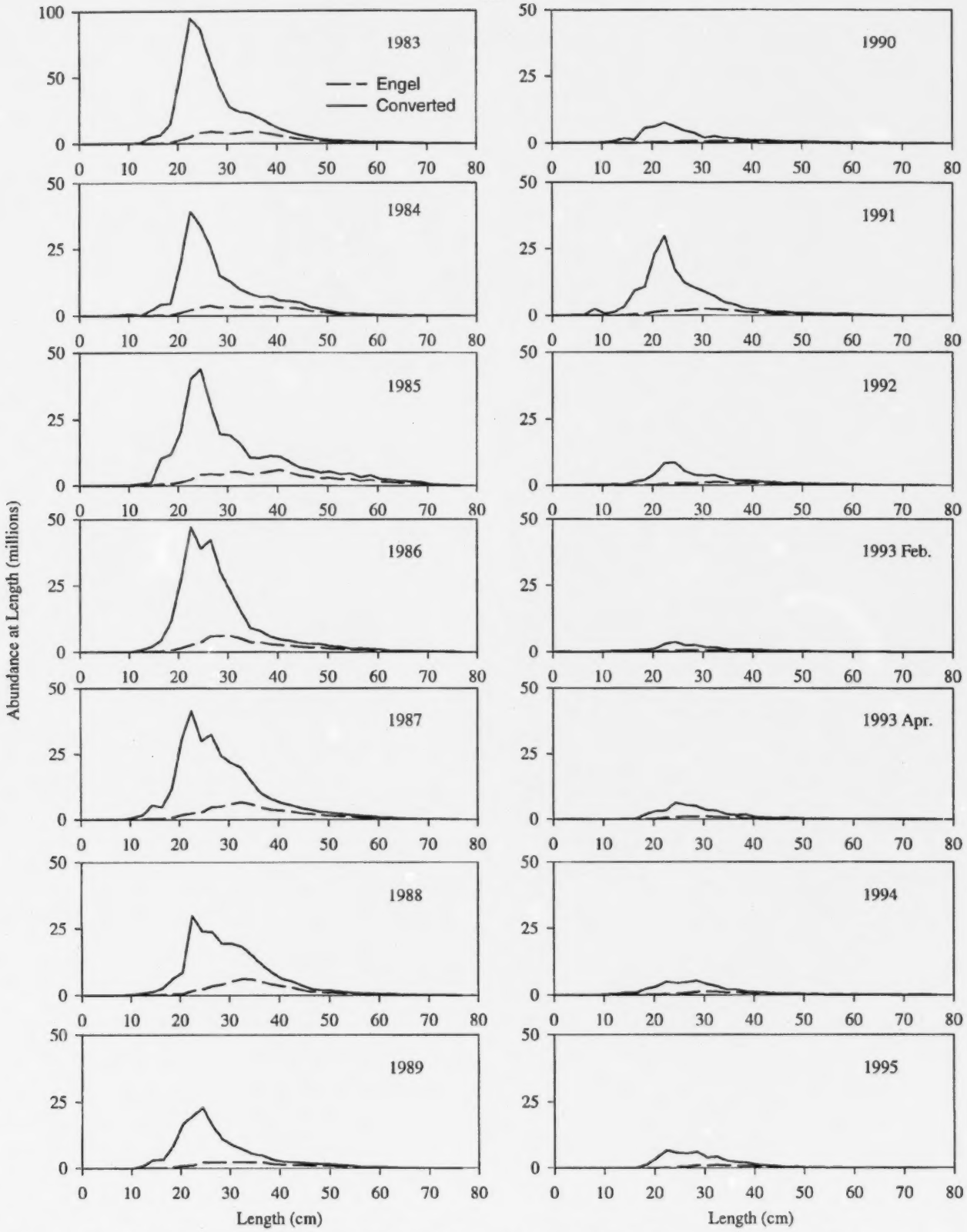

Figure 12. A comparison of abundance at length (cm) between the Engel trawl and Campelen catch equivalents for American plaice from Canadian surveys in Subdiv. 3Ps.

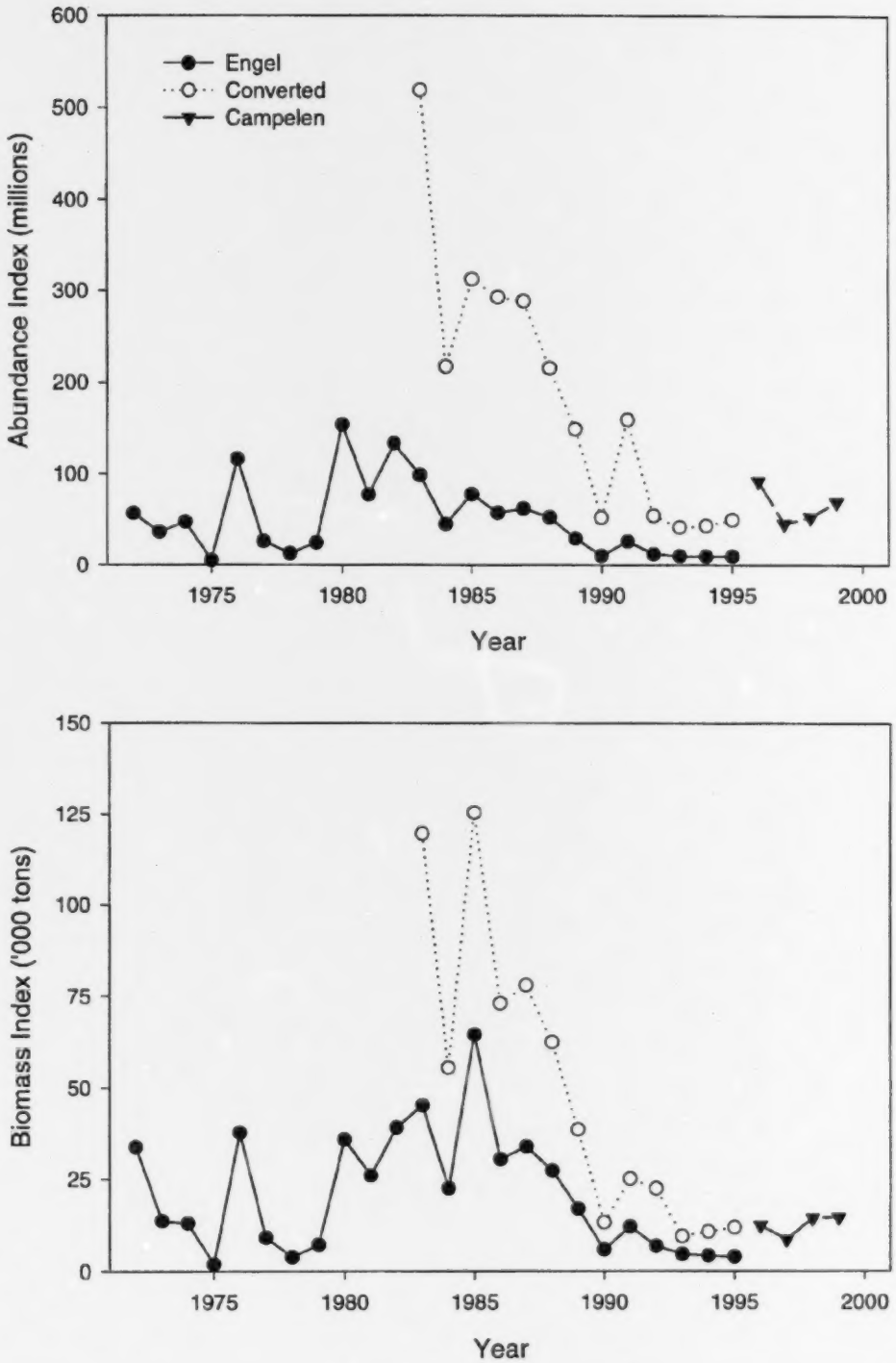

Figure 13. Abundance and biomass indices from research vessel surveys from 1972 to 1999. Original Engel (72-95), converted (83-95) and Campelen (96-99) data are shown. Data points for 1993 are from the April survey.

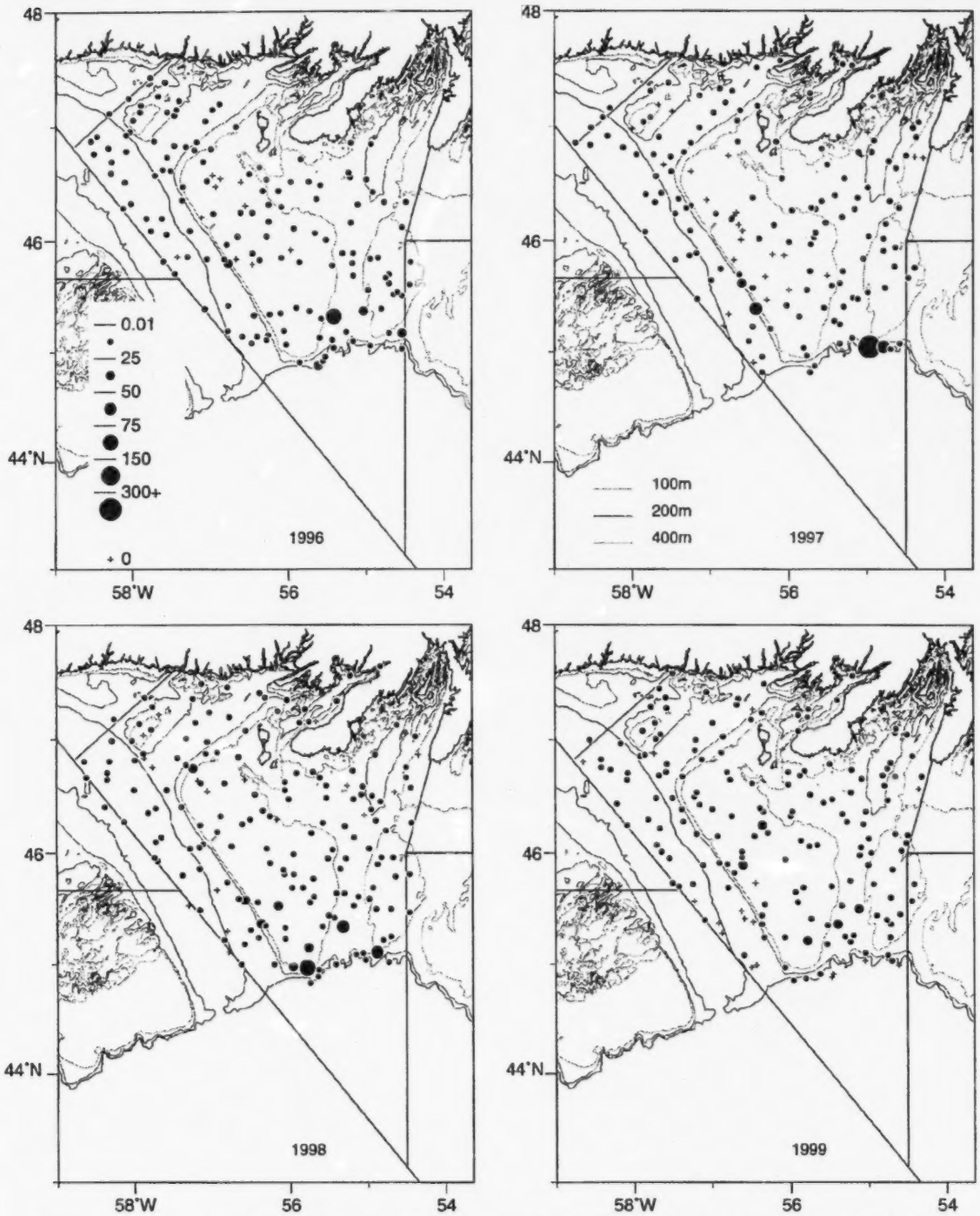

Figure 14. Distribution of American plaice (Kg) from Canadian research vessel surveys in NAFO Subdivision 3Ps from 1996-99.

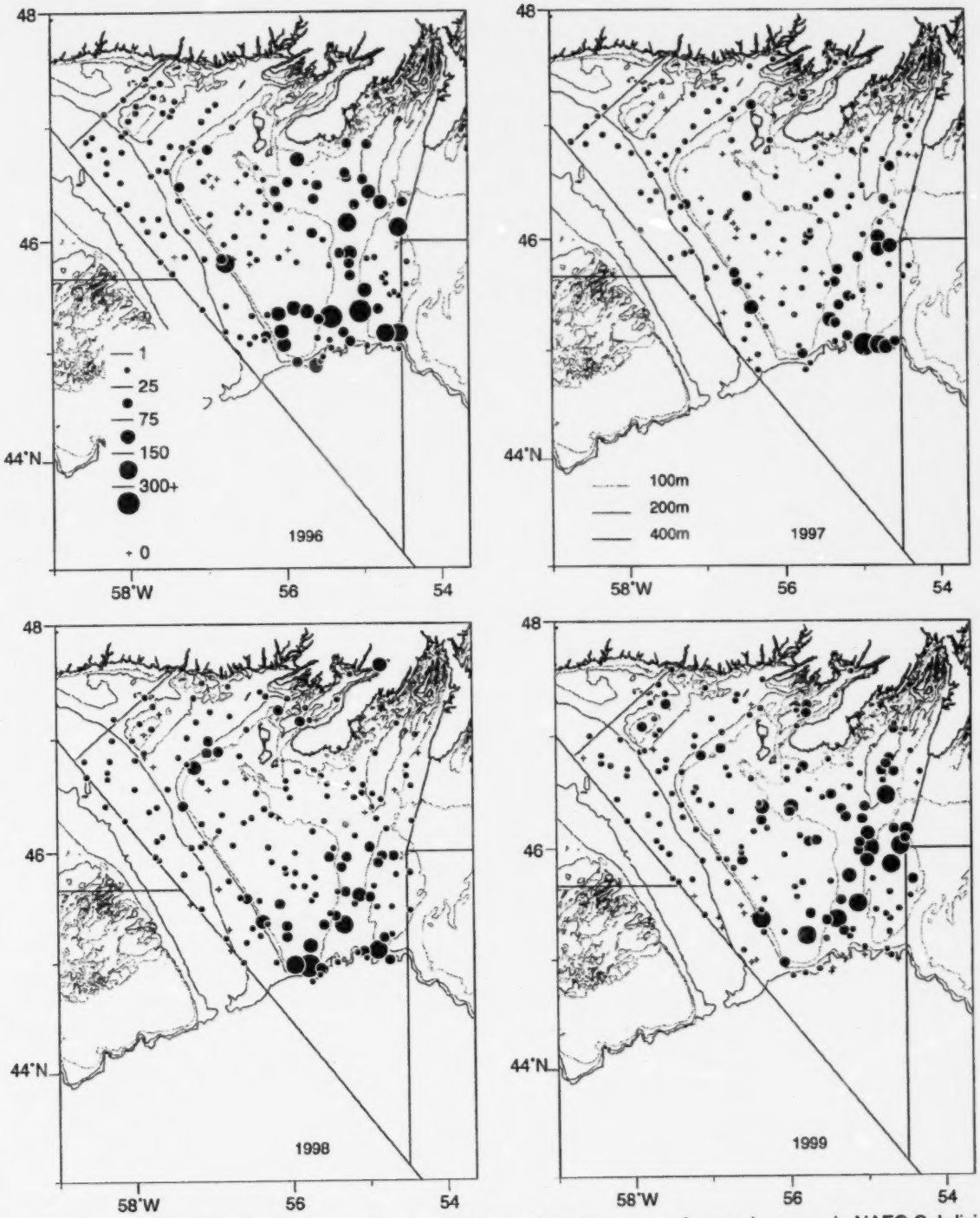

Figure 15. Distribution of American plaice (number) from Canadian research vessel surveys in NAFO Subdivision 3Ps from 1996-99.

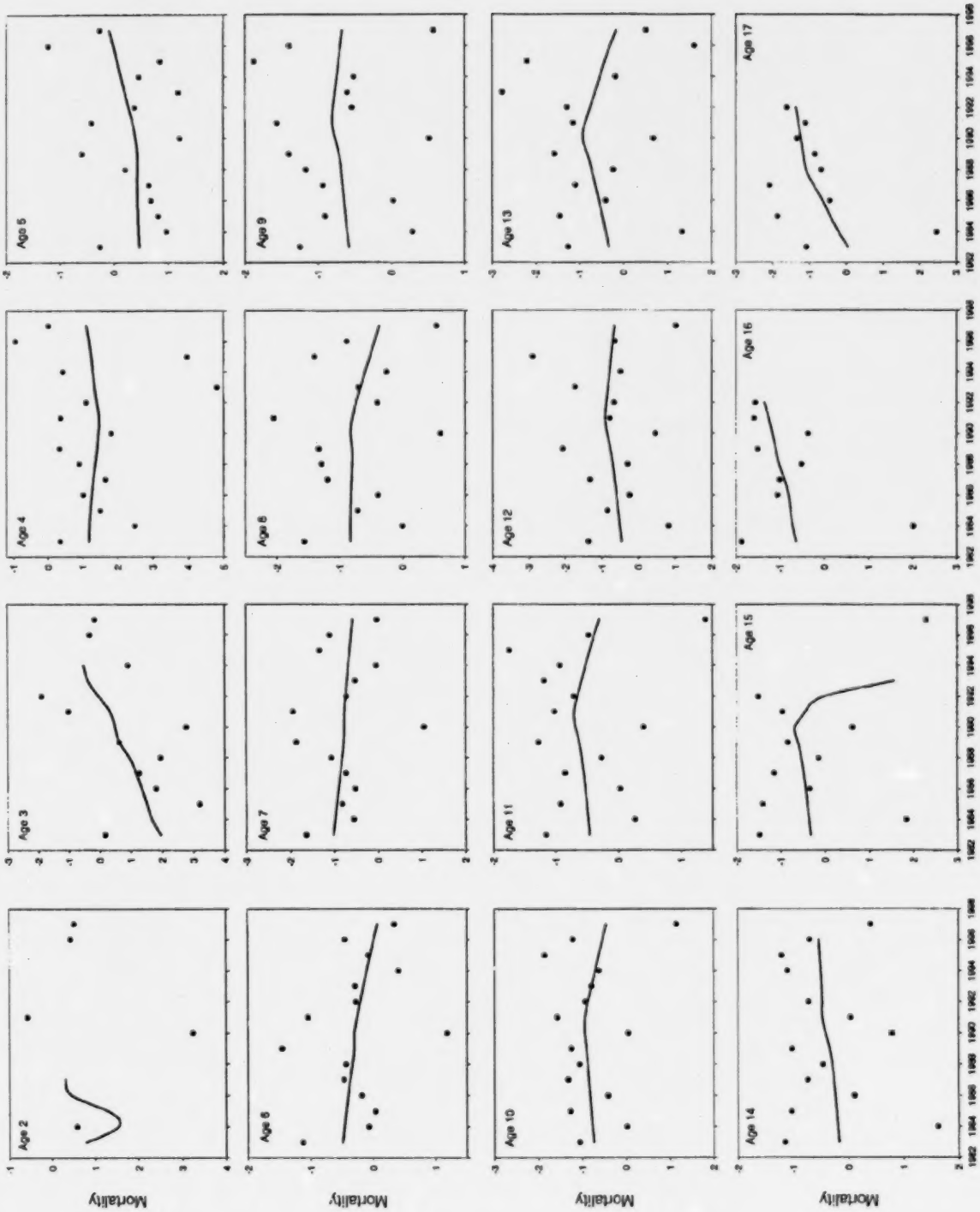

Figure 16. Estimates of mortality for ages 2 to 17 of American plaice from Canadian surveys in Subdivision 3Ps from 1983 to 1998.

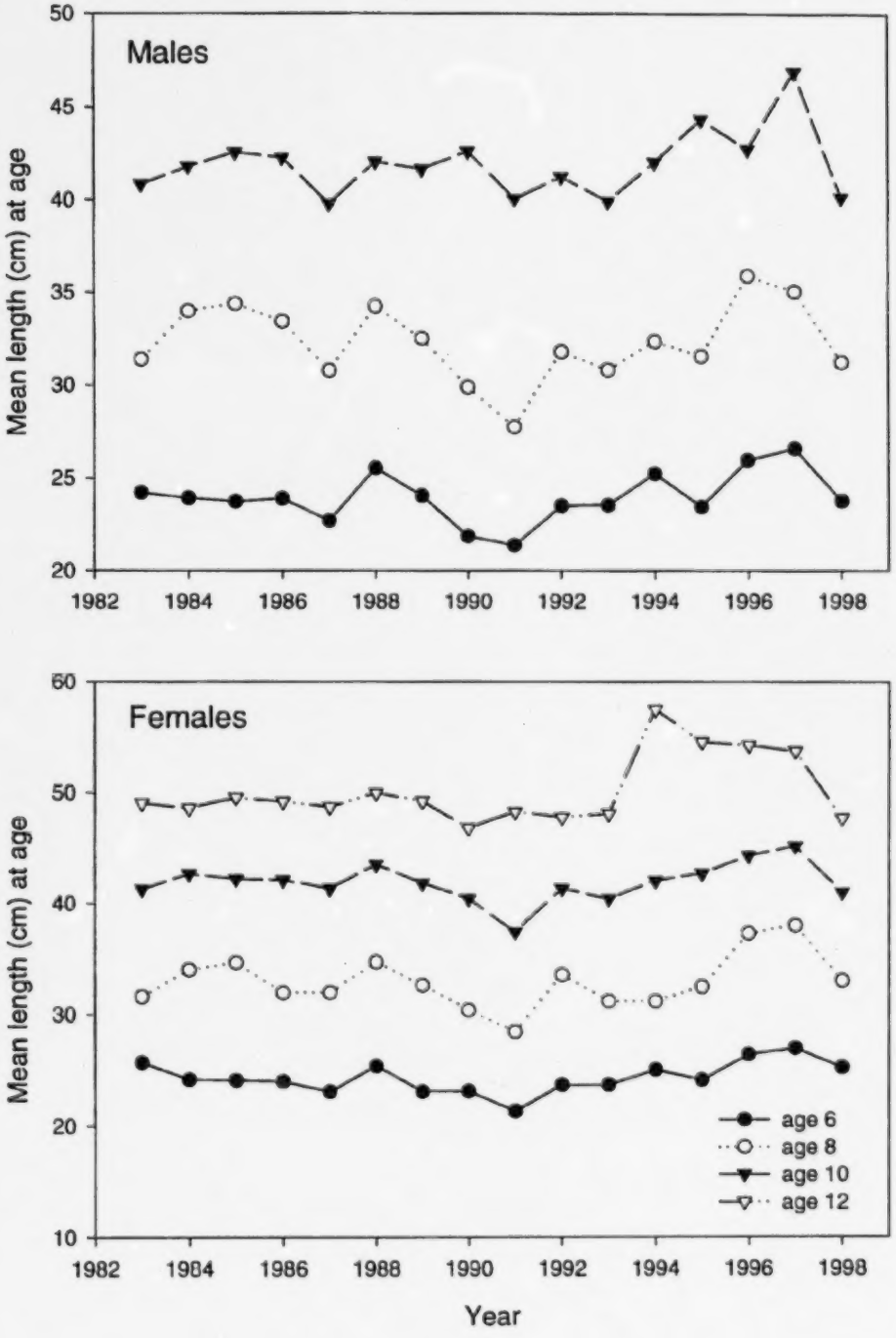

Figure 17. Mean length at age for selected ages of male and female American plaice in Canadian research vessel surveys form 1983-98.

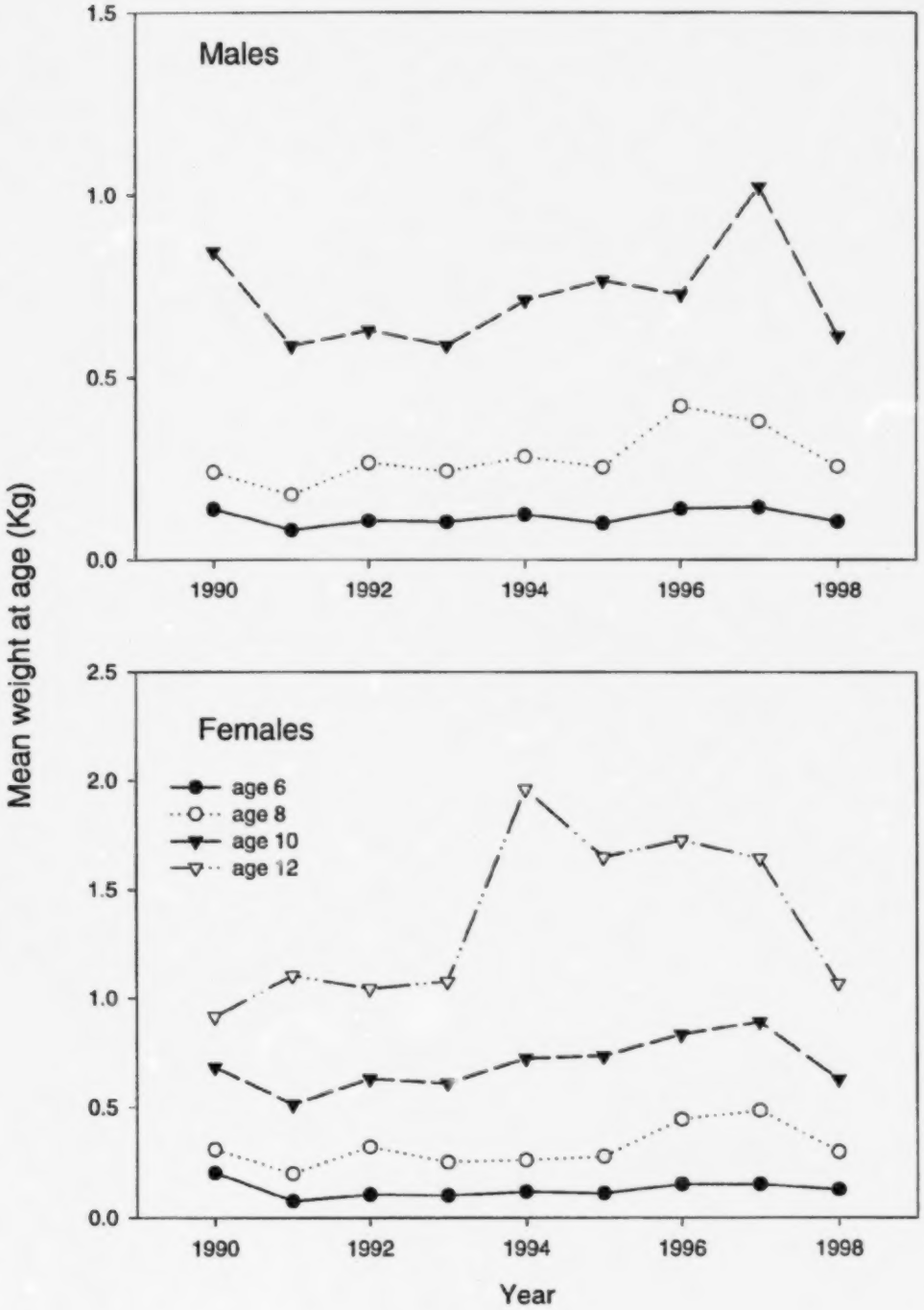

Figure 18. Mean weight at age for selected ages of male and female American plaice in Canadian research vessel surveys from 1990-1998.

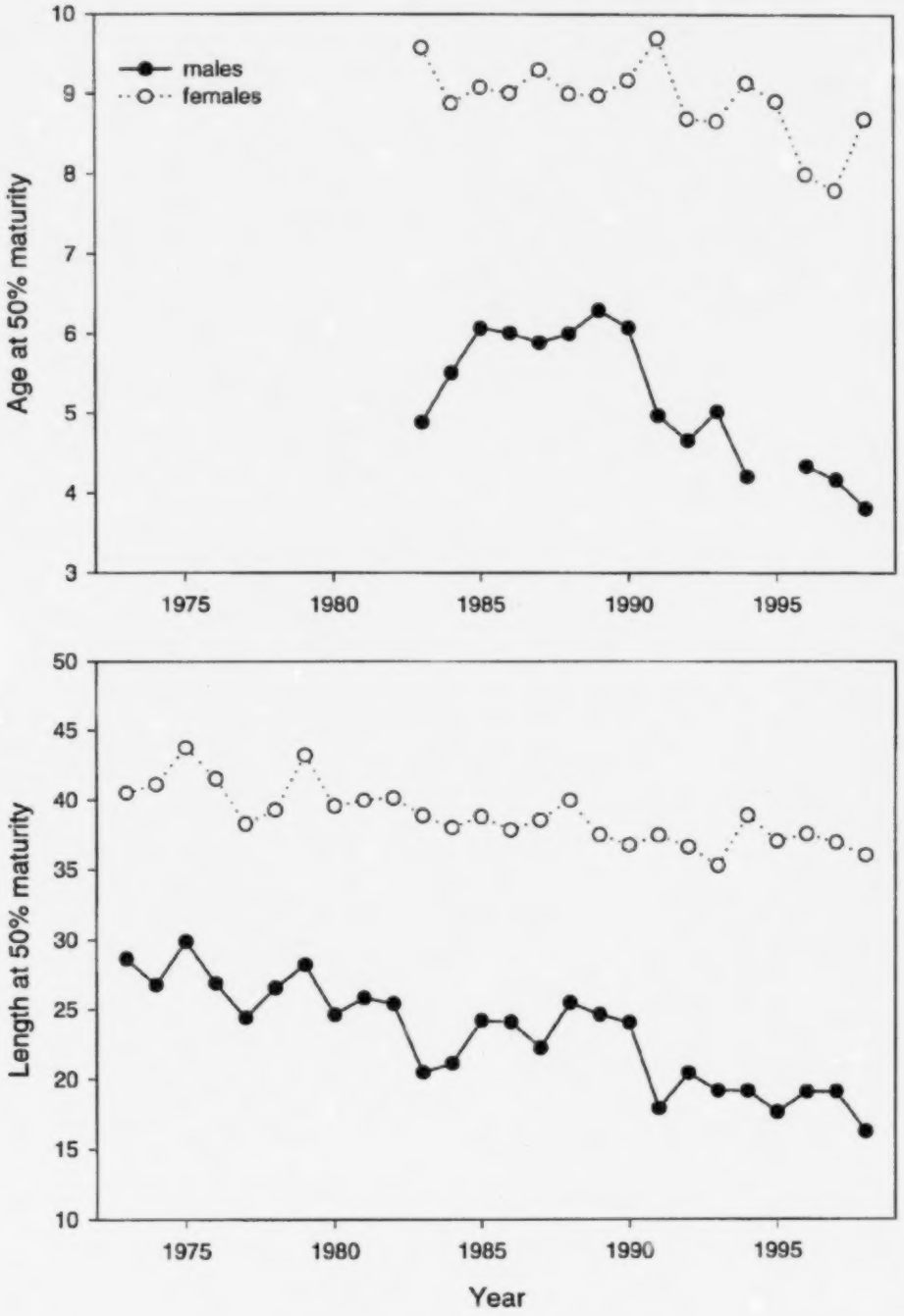

Figure 19. Age and length at 50% maturity for male and female American plaice from Canadian research vessel surveys in Subdivision 3Ps. Data for age at maturity are converted to Campelen equivalents.

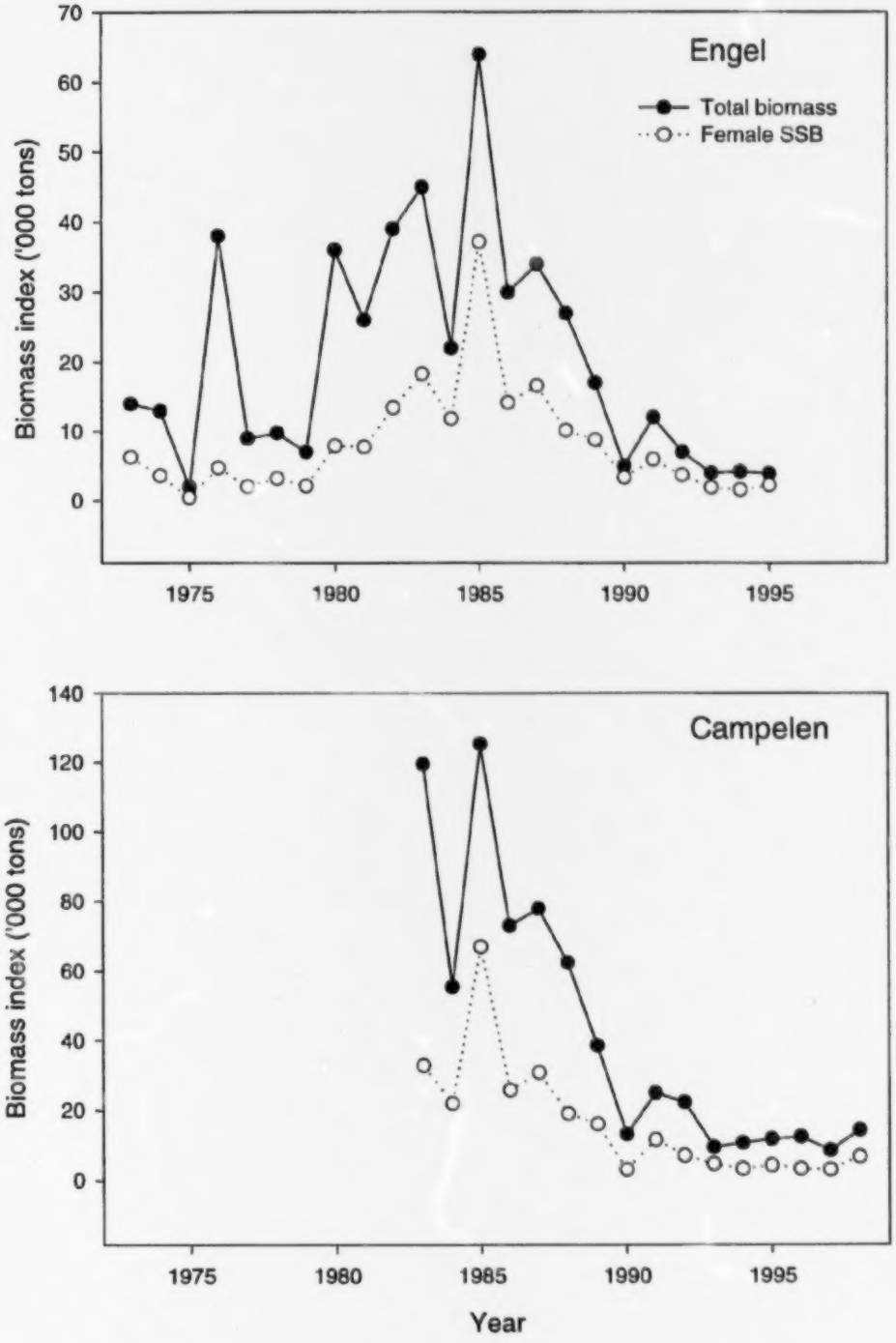

Figure 20. Total biomass index and female spawning stock biomass index of American plaice from Canadian research vessel surveys of Subdivision 3Ps for Engel (72-95) and Campelen (83-98) data.

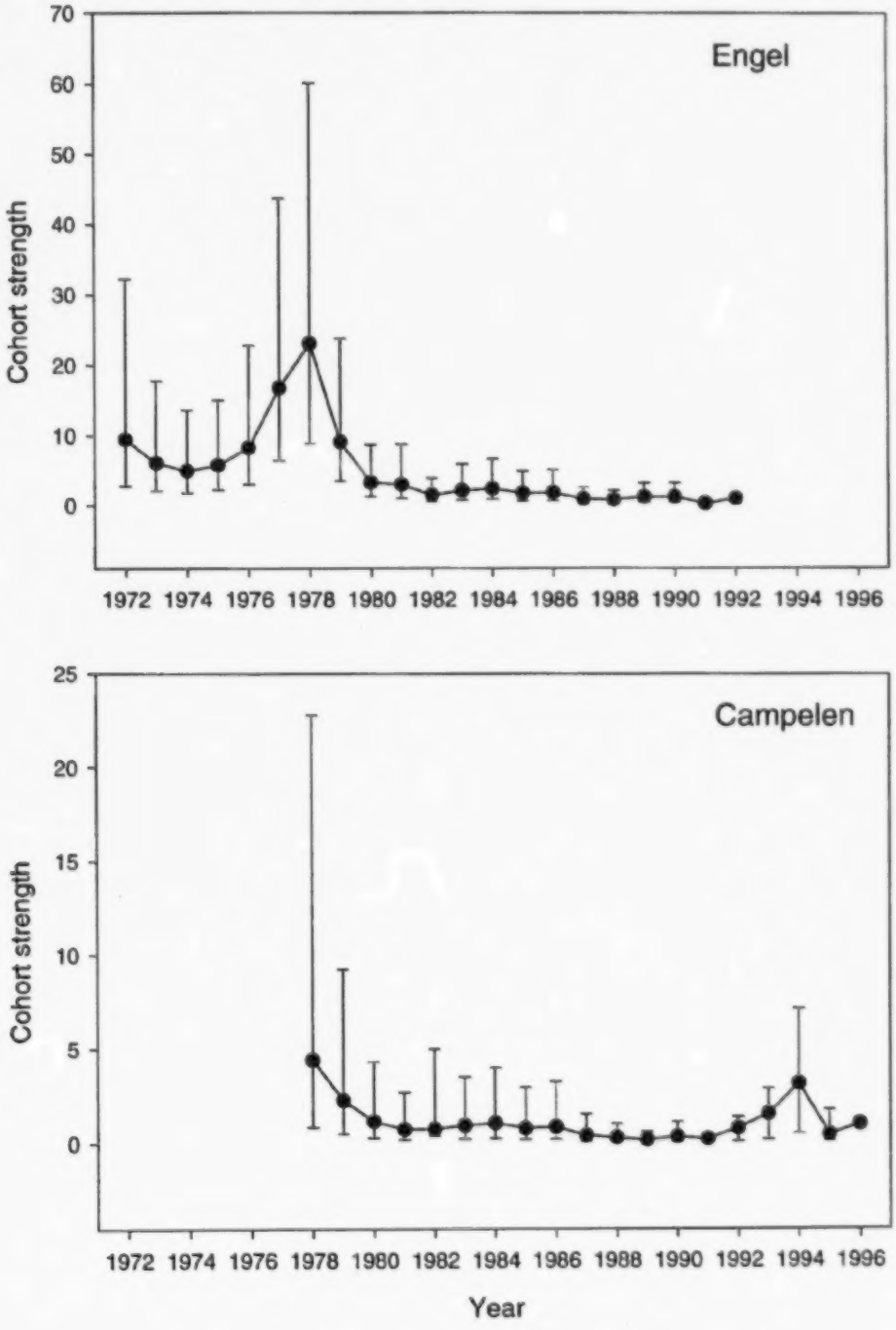

Figure 21. Cohort strengths of American plaice from multiplicative models of data from Canadian research vessel surveys in Subdivision 3Ps for Engel (72-92) and Campelen (78-96) data.

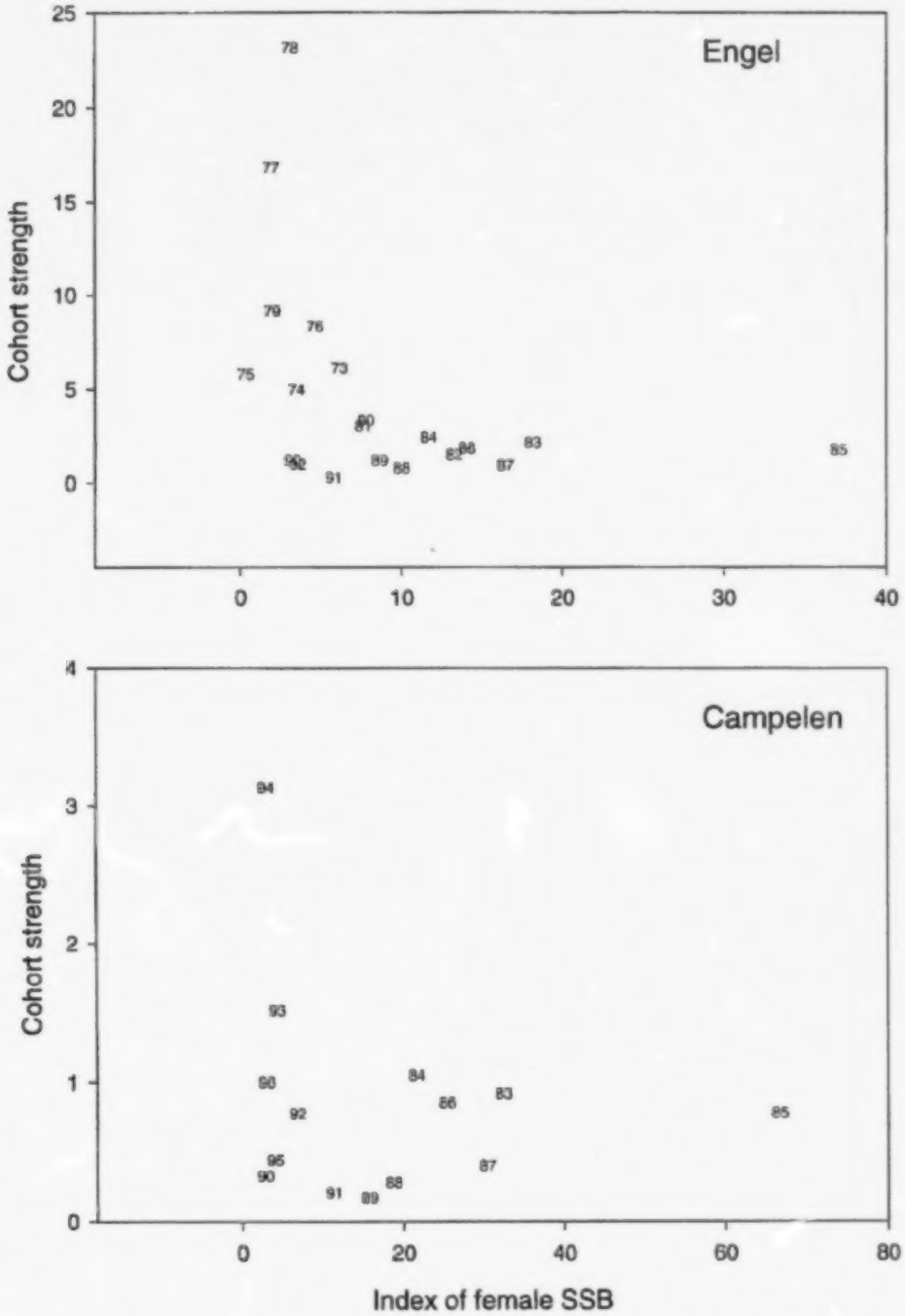

Figure 22. Cohort strength vs female spawning stock biomass index of American plaice from Canadian research vessel surveys for Engel (73-92) and Campelen (85-96) data. Cohort strengths are from a multiplicative model.

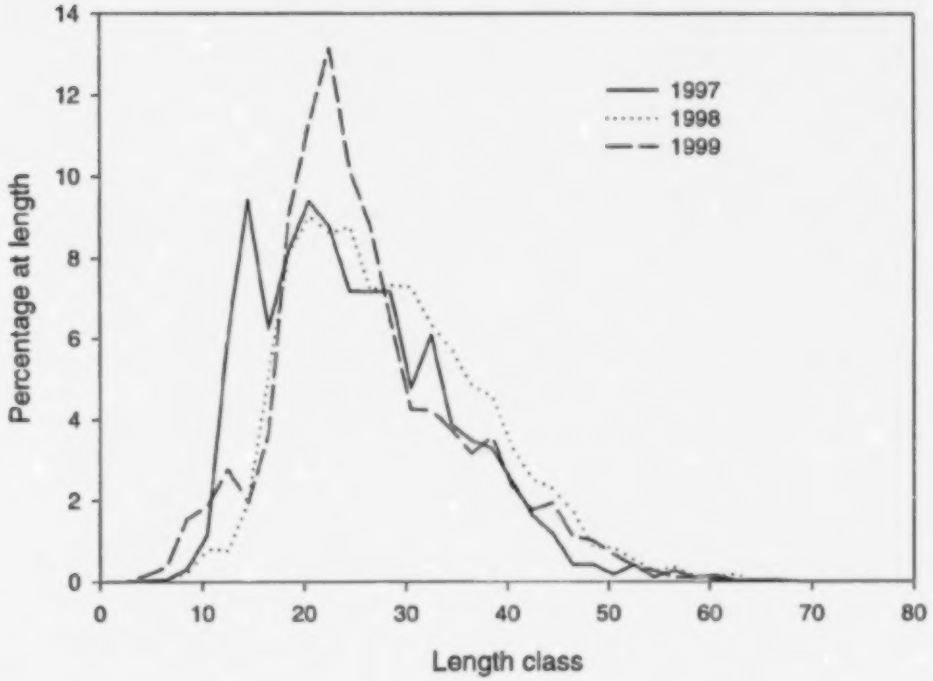

Figure 23. Percentage at length in the population of American plaice in Subdivision 3Ps as estimated from Canadian research vessel surveys in 1997-99.

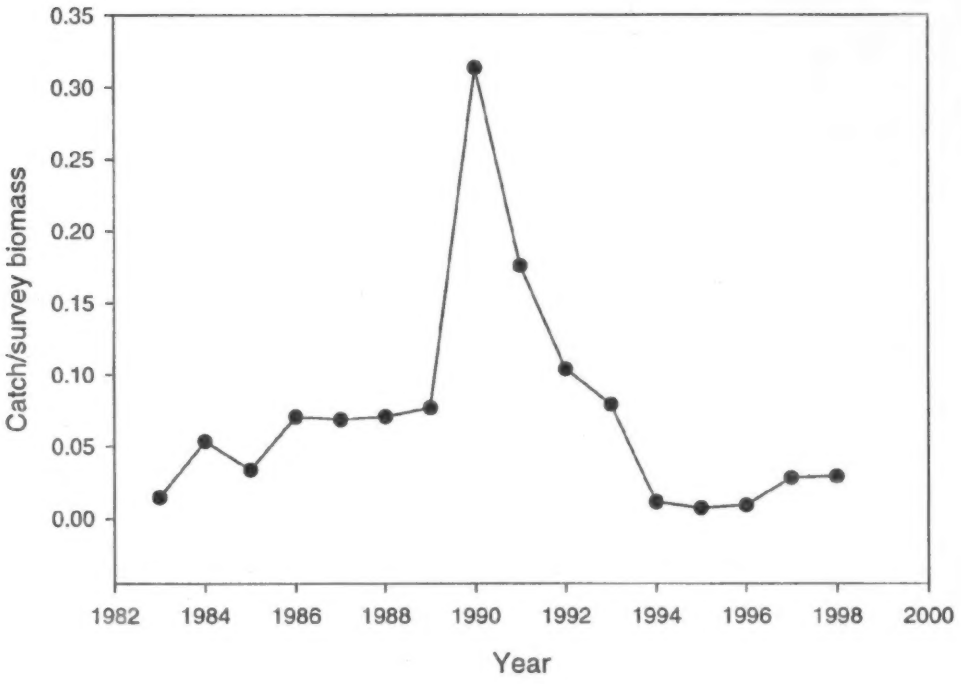

Figure 24. Catch to survey biomass ratio for American plaice in Subdivision 3Ps from 1983-98.